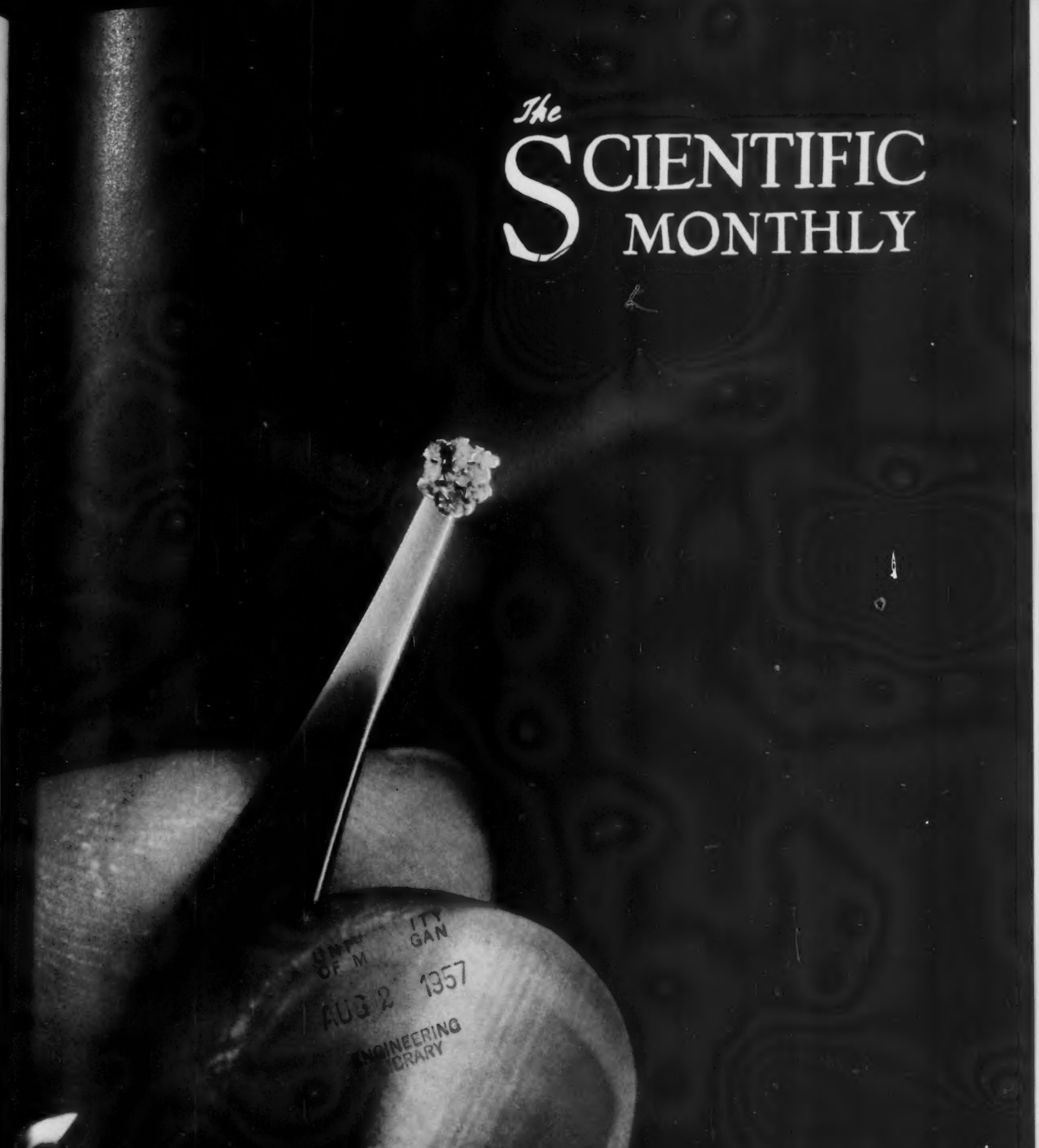
THE SCIENTIFIC MONTHLY

VOLUME 83
JULY TO DECEMBER

PUBLISHED BY
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
1515 MASSACHUSETTS AVENUE, NW, WASHINGTON 5, D.C.
1956

BUSINESS PRESS, INC.
LANCASTER, PENNSYLVANIA, U.S.A.

The SCIENTIFIC MONTHLY



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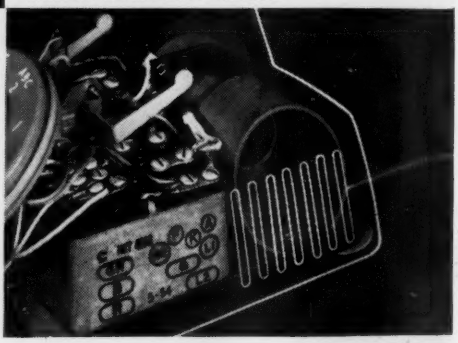
Transistorized telephone summons you with a musical tone

Above. Experimental model resembles regular "500" set; the only visible departure is a louver in the base through which the musical tone is radiated.



Above: Bell ringer has been displaced by a small loudspeaker in transistorized telephone. Left: L. A. Meacham heads the team of engineers that developed the musical tone ringer. Mr. Meacham holds a B.S. in Electrical Engineering from the University of Washington, Class of '29. He became affiliated with Bell Labs a year after his graduation. In 1939 Mr. Meacham won the "Outstanding Young Electrical Engineer" award of Eta Kappa Nu.

Bell scientists have developed a new musical tone device which may some day replace the telephone bell, if it meets technical standards and customers' approvals.

Because the musical tone equipment uses transistors, the tones will be transmitted with the same amount of power required to transmit a telephone conversation—considerably less than is needed to make a telephone bell ring.

The experimental telephone sets resemble the current "500" sets; the only external difference is a louver at the side of the base through which the tone is radiated by a small loudspeaker mounted inside the telephone's base.

Tests have shown that the musical tone can be heard at great distances. It stands out above general room noise and can be distinguished from sounds like ringing of doorbells or alarm clocks.

This new low-power signaling technique is expected to play an important part in the electronic switching system now under development at Bell Telephone Laboratories.

BELL TELEPHONE LABORATORIES

World center of communications research and development

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Cover: Man-Made Diamonds

[*Courtesy General Electric Research Laboratory, see page 21*]

THE SCIENTIFIC MONTHLY, established in 1872 as *The Popular Science Monthly*, has been an official publication of the American Association for the Advancement of Science since 1915. It is published for the Association at Business Press, Inc., Lancaster, Pa.

All correspondence should be addressed to THE SCIENTIFIC MONTHLY, 1515 Massachusetts Ave., N.W., Washington 5, D. C., Manuscripts should be typed with double spacing and submitted in duplicate. The AAAS assumes no responsibility for the safety of manuscripts and photographs or for the statements and opinions expressed by contributors.

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THE SCIENTIFIC MONTHLY is indexed in the *Reader's Guide to Periodical Literature.*

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Science and Technology

(From the month's news releases; publication here does not constitute endorsement.)

Double-Crystal X-ray Diffractometer

A perfect crystal that functions as an analyzer for any test crystal being investigated is incorporated into a recently developed x-ray diffractometer. Maximum resolution is obtained by reflecting the x-ray beam into the collimator from this crystal. Slit systems at the collimator ends screen out the alpha-2 component. Film from the photographic unit functions as a guide for the Geiger counter in disclosing substructural details of the sample. (New Brunswick Scientific Co., Dept. SM, P.O. Box 606, New Brunswick, N.J.)

Plasticizers

Two new plasticizers have been introduced by Rubber Corporation of America. One of these is a blend of di-isodecyl phthalate and di-isodecyl adipate that functions as a low-temperature plasticizer for polyvinyl chloride. It exhibits low volatility and high heat stability. The other product, called DIDP-10, has been formulated for wire coating application and like purposes. It is designed to improve low-temperature brittle points in polyvinyl chloride compounds while maintaining the low volatility that is characteristic of higher phthalate esters. (Rubber Corporation of America, Dept. SM, Hicksville, N.Y.)

Cathode Interface-Resistance Tester

An instrument was recently developed for measuring the interface resistance of vacuum tubes that results from oxide formation under cathode coatings. The instrument utilizes the Wagner two-frequency method, with a sensitive vacuum-tube voltmeter circuit to compare interface resistance with a known resistance. Changes as small as 1 ohm/1000 ohm can be measured with an accuracy of ± 2 ohm, or ± 3 percent, whichever is greater, over a range from 0 to 1100 ohm. (Manson Laboratories, Dept. SM, 207 Greenwich Ave., Stamford, Conn.)

Enzyme System

A glucose oxidase-catalase system is described in a bulletin recently issued by Fermco Chemicals. The report discusses the effect of changes in temperature, concentration, and *p*H on the system in use as a soft-drink stabilizer. (Fermco Chemicals Inc., Dept. SM, 4941 S. Racine Ave., Chicago 9, Ill.)

Depth Sounder

An echosounder, suitable for use in small boats, indicates water depths to 270 ft. It operates from a 12-v battery. (Pye Marine Ltd., Dept. SM, Lowestoft, England)

Spectrographic Supplies

A catalog of spectrographic supplies includes information on pure materials and alloy standards, plates and films, and graphite electrodes and powders. (Jarrell-Ash Co., Dept. SM, 26 Farwell St., Newtonville, Mass.)

Distilled Water Regulator

An instrument that automatically regulates the purity of distilled water has been developed. It is adjustable on a 0- to 15-ppm scale. The electric resistance of the distilled water determines whether it will enter the storage tank. The unit includes purity meter, continuous-flow cell, thermometer, threaded-glass conductivity cell, signal light, automatic diverter valve, and fittings for effluent line. (Barnstead Still and Sterilizer Co., Dept. SM, 2 Lanesville Terrace, Forest Hills, Boston 31, Mass.)

Traducer

An ultrasonic traducer for cleaning, plating, and other physical and chemical processes is sealed, metal-jacketed, and thermostatically protected. Its resonant frequency of 20 kcy/sec provides maximum cavitation energy above the range of human perception. It is powered by a generator that is continuously variable in frequency from 10 to 1200 kcy/sec and has an output of 400 w. (General Ultrasonics Co., Dept. SM, 1240 Main St., Hartford, Conn.)

Commercially Available Chemicals

Chemicals that are commercially available are listed and described in a 370-page book compiled by Fisher. It includues 7300 compounds from technical grades to radioactive reagents and spectroscopically pure solvents, along with bacteriological culture media, fluid extracts, spirits, and tinctures. This reference book gives structural formulas, formula weights, melting and boiling points, and color-index numbers of the compounds. (Fisher Scientific Co., Dept. SM, 415 Forbes St., Pittsburgh 19, Pa.)

Electrolytic Water Analyzer

An analyzer for the measurement of small quantities of water in gas streams registers water content down to less than 1 ppm, weighs less than 50 lb, and is portable. The instrument operates by passing the wet stream over a hygroscopic substance that is electrically conductive only when it is wet. Quantitative electrolysis takes place and the water content is determined as a function of the electric current. (Manufacturers Engineering and Equipment Corp., Dept. SM, Hatboro, Pa.)

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Tektites and the Lost Planet

RALPH STAIR

Mr. Stair, a physicist, received his training at the University of Missouri and at George Washington University. Before he attended George Washington, he taught physics and mathematics in various high schools in Missouri. During the past 30 years, he has worked on radiometric researches in Washington, D.C.

TEKTITES are small glass objects that have fallen to earth from outer space. Occurring in great quantities, they have been collected casually by some persons, but more often have been overlooked. Tektites served the cave dwellers of paleolithic times as weapon points; they were picked up as curios in Australia during the early days of the gold rush; and they were used as jewels and ornaments in Texas, where they were known popularly as black diamonds (*1*). Recently tektites have become of interest to cosmologists. The study of the properties of these small glass objects may well lead to a better understanding of the origin of the solar system, and possibly of the universe itself.

Tektites have fallen in many places and are known to scientists by many names. When found in Australia, they are called australites; when found in the Philippines, rizalites; in Texas, bediasites; in Bohemia, moldavites. They are also called Darwin glass and Libyan Desert glass. The tektites found in a given location are sufficiently alike in their physical and chemical properties, in contrast to other specimens, to establish them as an independent subfamily group (*2*). A fall usually is spread over a considerable area. In the case of the australites, the area includes the south half of Australia as well as a number of the outlying islands.

Tektites usually vary in weight from a fraction of an ounce to almost a pound. In shape they range from irregular objects to such symmetrical forms as buttons, spheres, ovals, pears, dumbbells, teardrops, winged bodies, rods, and disks. In color, tektites vary from black to a dark shade of green. Thin polished sections, however, range from nearly transparent through various shades of green to amber or brown.

Composition and Origin

A study of the composition and other characteristics of these glasses has revealed many facts that form the basis for interesting deductions regarding their origin. They have a high silica content, with the major secondary constituents being the oxides of aluminum, iron, magnesium, calcium, sodium, and potassium (see Table 1). In composition, they do not resemble either any igneous rock structure (*1*) of the earth (they differ radically from obsidian) or that of any glass that has been produced since the beginning of glass manufacture. Although certain sedimentary rocks within the earth's crust have approximately the same composition, it is generally agreed that no natural heat source has existed on the earth within recent geologic time that is capable of producing temperatures sufficiently high to fuse this type of glass, especially since its melting point is nearly 200°C above that of presently manufactured Pyrex glasses.

Table 1. Some tektite glass compositions (percentage), specific gravity, and index of refraction data as reported by V. E. Barnes (*1*). The numbers in parentheses in the column headings refer to authorities listed by Barnes.

Item	Billitonites (50)	Australites (58)	Philippines (44)	Indochinites (33)	Bediasites (16)	Moldavites (11)	Darwin glass (1)	Libyan glass (65)
Composition								
SiO_2	70.30	70.62	71.20	72.26	77.76	80.73	86.34	97.58
Al_2O_3	12.77	13.48	13.52	13.18	13.30	9.61	7.82	1.54
Fe_2O_3	0.53	0.85	0.59		0.37		0.63	0.11
FeO	5.43	4.44	3.89	5.32	3.36	1.93	2.08	0.23
MgO	3.74	2.42	2.23	2.15	1.19	1.59	0.92	Trace
CaO	2.37	3.09	3.40	2.42	0.04	2.13	0.05	0.38
Na_2O	1.73	1.27	1.59	1.43	1.41	0.37	0.15	0.34
K_2O	2.48	2.22	1.84	2.15	1.97	3.60	0.87	None
H_2O	0.08	0.07	0.63	0.20	0.02	0.02	0.46	0.10
TiO_2	0.50	0.90	0.92	0.99	0.76	0.32	0.52	0.21
MnO	0.13	0.42	0.08	0.10	0.01	0.07	None	Trace
Specific gravity	2.48	2.454	2.436	2.440	2.357	2.343	2.296	2.208
N_{Na}	1.527	——	——	1.5133	1.492	1.487	1.474	1.4624

These facts, together with the many special shapes encountered, definitely indicate a flight through the earth's atmosphere at a velocity sufficient to ablate the surfaces of the tektites. The winged types, in particular, present an unchallengeable proof that the glass surface has been heated to the liquid phase and simply blown off the rear of the specimen, forming a circular apron at its base. Figure 1 shows a fragment of such a tektite that was picked up in Australia. In fact, many stony meteorites also show a glasslike flow over their surfaces. Hence, tektites must be travelers from out of space as are the other types of meteorites. Although some investigators believe that these glass bodies are of terrestrial origin (*1*, *3*), the preponderance of evidence seems to point to a cosmic source as the origin (*4–7*). The big questions are as follows: From where did they come? How and when and where were they formed?

Ordinary meteorites arrive at the earth's surface in all manner of sizes and shapes. They arrive at various speeds not exceeding about 50 miles per second, as determined by visual and radio measurements on their velocities and directions (*8–10*). Most of them, at least, must therefore be following elliptical orbits and are a part of our solar system. Furthermore, more meteors have a direct (rather than a retrograde) motion and therefore in general line with the planets and major asteroids. Their compositions vary in unbroken sequence from that of nickel-iron to stone that is similar to certain types of terrestrial rocks. (No meteorite, however, is anything like granite or the acidic volcanic rocks). These and other observations made during the past century support the suggestion made by Boisse in 1850 (*11*) that a study of meteorites should result in an understanding of the earth's structure and composition (*12*) for meteorites possibly came from a former planet that had physical and chemical characteristics similar to those of the earth. Today few scientists doubt the hypothesis that meteorites were once a part of a parent planet (or planets) that circulated around the sun in a fashion similar to the observed motions of the remaining planets of our solar system.

Tektites differ from other meteorites in two important ways. First, they are of glass—a very special glass—that has a high melting point, a low coefficient of expansion, and a high durability. Second, they are found only in small pieces and usually in special shapes.

Let us try to answer the question of their formation first—that is, how and where. Studies of the many meteorites that have landed on the earth, many of which may be observed in various museums throughout the world, support the hypothesis that they were once a part of a planet or other cosmic body. In the development of these parent bodies, it is to be expected that the process was one of the slow accumulation of the cold particles and gases that compose the cosmic dust. The bodies would originally have been cold (*13–15*) but heat would have gradually developed as the planetoid's mass increased. Heating would result not only from the dissipation of potential energy in the contracting process but also from radioactivity and chemical reactions supplemented in a small way by radiant energy from the sun. As a result, the planetoid would become heated, the magnitude of

the resultant temperature and the degree of the settling and/or boiling processes depending on the masses involved. For a planet of the earth's order of magnitude, it has been estimated that the temperature would reach, or exceed 3000°K (*16, 17*).

If the temperature should reach a level sufficiently high to melt the major components of the planetoid, it is expected that there would result a concentration of the heavier materials in the planet's core, with lighter and lighter material tending to attain chemical and physical equilibrium at higher levels as the various chemical reactions were concluded. Thus the lightest substances, the glasses and glassy silicates, would become concentrated in layers or pools on or near the surface of the planet. If the planet had been small—that is, of the order in size of our moon or the planet Mars—the materials composing it would have accumulated without appreciable chemical separation (*14, 18*), as has been the case with these two members of the solar system. Hence, to account for the resulting temperatures and separations of the different metal and stony phases (illustrated by the different types of meteorites), a planet approximating the earth in size and general physical and chemical characteristics is required (*12*).

From this picture, we have a planet with a nickel-iron core surrounded with troilite (principally ferrous sulfide) and olivene (a magnesium and iron silicate) and topped with the glassy silicates and glasses. The glasses should be uppermost—that is, on or near the surface. After the outer crust had been formed, volcanic processes similar to those within the earth would be expected to be operative. Indeed, meteorites in various museums clearly show that the process by which they were formed was very complex. There was extensive mixing, crushing, melting, segregation, remelting, and so forth. In fact, no theory has yet been proposed that will account for many of the different structures that are displayed by the polished surfaces of meteorites.

No sedimentary rocks, such as shales, limestone, or others, or structures proving the presence of any type of plant or animal life have ever been observed in any meteorite found anywhere. That is, no water erosion or organic chemical reactions have left traces within any meteoritic material. Although carbon compounds have been reported in 20 (*19*) carbonaceous chondrites, carbon in meteorites is always found in an inorganic form. The carbon may be present in combination with nitrogen, oxygen, hydrogen, sulfur, and chlorine or as carbide, graphite, diamond, or amorphous carbon. If this meteoritic planet was originally located between the orbits of Mars and Jupiter, temperature conditions would have been such that any water present would necessarily have been in the solid state (ice). Therefore, surface glass formations should have remained somewhat in their original state. The fact that some of the sedimentary material near the earth's surface approximates the tektite glasses in composition may indicate that the surface layer of the earth was once of similar glassy structure that became eroded and transformed into the sedimentary rocks. It is more likely, however, according to Urey (*19*) that the present composition of the sedimentary rocks has resulted from water weathering, in which a number of the elements, in particular calcium and magnesium, have been removed and deposited as limestone and dolomite elsewhere.

Tektite glasses, which must have been located somewhere on or near the surface of the meteoritic planet, have fusing or melting points and general physical characteristics in the form of striae, strain, inhomogeneity, and so forth, that call for a forming temperature between about 1500° and 2500°C. It should be noted at this point that glasses of this type are not producible as flash products resulting from a collision or short-period heating by other means. Long periods of time are required for the different oxides composing the glass to fuse properly and to mix into a more or less homogeneous glass product. During this time, the temperature

Fig. 1. Fragment of australite illustrating a winged tektite having an apron resulting from partial fusion in flight (×3.5). [Courtesy W. A. Cassidy, South Australian Museum]

must be well above the melting point of the glass. Temperatures too high, on the other hand, would vaporize certain components of the glass.

However, the general character of all the tektite glasses indicates incomplete mixing, as is to be expected under conditions in which new materials are constantly being added to the glass batch. The fact that certain of the alkalies remain within the glass is an important consideration in any study of the temperature conditions under which the tektites were formed. The presence of oxygen in combination with the various metals that form the basic structure of the glass serves as conclusive evidence of the existence of that element in considerable amount on the meteoritic planet at the time the tektite glasses were formed. Simulated laboratory tests in the making or melting of glasses of similar composition (or, better, with some of the tektite glasses) should result in very useful information regarding the conditions under which the tektite glasses were formed. If the glass were heated to higher and higher temperatures, certain of the oxides would be expected to successively boil off, leaving glass of such composition as to make possible a correlation between the glass composition and the temperature conditions under which it was made.

A study of the spectral transmission properties of thin slices of tektite glass offers a convenient means of obtaining certain information concerning their physical and chemical constitution. Many other avenues of investigation are awaiting exploration. The transmission curves in the ultraviolet, visible, and infrared for some of the tektites are given in Figs. 2 to 5 (*20*). The ultraviolet and visible transmission properties of a number of australites (Fig. 2) and of a group of bediasites (Fig. 3) illustrate the family character of specimens of this glass that were picked up at scattered loca-

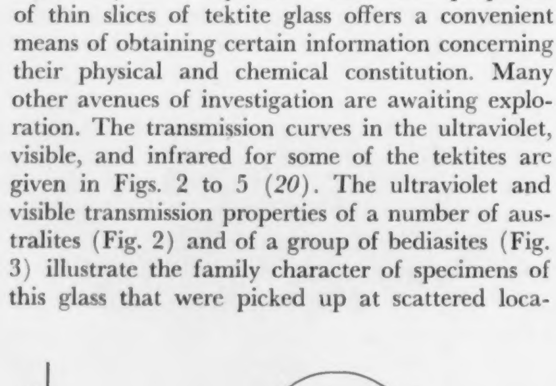

Fig. 2. Spectral transmittances of five australites. [Sample *A* from South Australian Museum; others from H. H. Nininger]

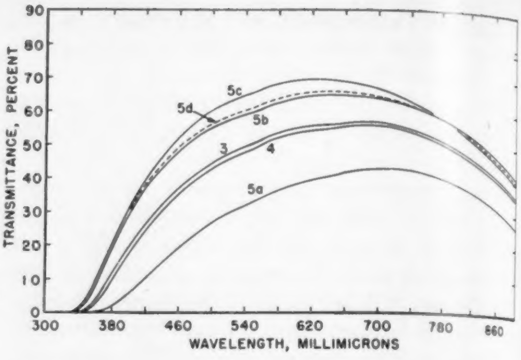

Fig. 3. Spectral transmittances of six bediasites. No. 3 is from near Muldoun, Fayette County, Tex.; No. 4 from eastern portion of Lee County, Tex.; and Nos. 5*a*, 5*b*, 5*c*, and 5*d* from near Bedias, Grimes County, Tex. [Courtesy Virgil E. Barnes, University of Texas]

tions in the two cases. The curves of Figs. 4 and 5 illustrate the types of variations in transmission properties that may be expected between samples from different tektite falls. An examination of these transmission data in relation to the values for chemical composition given in Table 1 is an example of just one method of scientific investigation into the physical and chemical properties of these glasses.

Disruption of the Meteoritic Planet

Now that we have the tektite glasses, as well as the other glassy silicates, together with the other meteoric material located within a planet (or planets) that is possibly between Mars and Jupiter, we may ask, What Next? That is a big question. If the tektites made up a small part of a large solid body that had the general characteristics of a planet similar to the earth, then that body must have been broken up for some reason, but how? Not because of an atomic or super bomb made by intelligent beings—there were none. There could have been an atomic explosion, or even a collision with a stray planet from outside the solar system. It is believed, however, that the answer is simple and logical and that it is to be found elsewhere. Suppose, for example, that two planets existed within this region of the solar system. These planets would have been acted on by the giant planet Jupiter in such a way that their individual orbits would have been constantly changed (*21*) relative to each other and to Jupiter. Under such a situation, anything might happen—for example, given enough time, a collision between them would ultimately result.

The solar system had its beginning some 4500

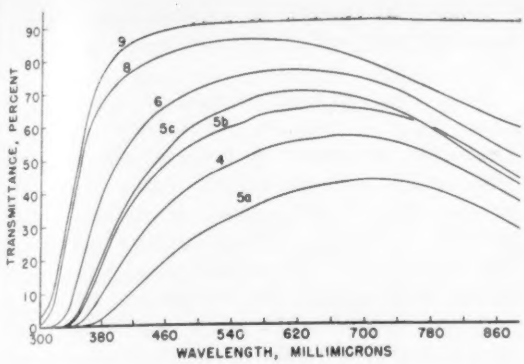

Fig. 4. Spectral transmittances of seven tektites from various sources. No. 9 is a Libyan Desert glass from Egypt; No. 8 a moldavite from Radoivibix, Bohemia; No. 6 from Empire, Ga.; the others are bediasites from Texas (see Fig. 3).

million years ago. Presumably the parent bodies of the present meteorites and comets (also tektites) had their origin about this same time. Attempts to measure the age of meteorites, and also of tektites (since their separation from the parent body) have been made by a study of various atomic changes within their composition (*22–27*). Not only do the different determinations vary, but studies on different meteorites result in various ages ranging from less than 1 million to almost 7000 million years (*23, 27*). It has been suggested by Urey (*18*) that some meteorities may have lost their radioactively formed gases through being heated on close approach to the sun, while Paneth (*28*) and others have pointed out the possibility of the repeated melting and solidifying of portions of the parent meteoritic body. In addition, diffusion of gases from and into the more porous samples has presented difficulties. Although some specimens indicate an age approximating that of the universe itself, other data indicate that many meteorites have their origin at a much later date, possibly within the last few hundred million years. Hence, it may be that some 1000 to 4000 million years elapsed between the creation of the universe and the formation of the meteorites resulting from planetary collisions. During this time, the planets would have made hundreds of millions of revolutions about the sun and thus would have had an opportunity to suffer great orbital changes even if they were only slightly perturbed each time they approached the vicinity of Jupiter.

Certain evidences favor the hypothesis that the planetary source of the recovered meteoritic samples was such as to allow their formation at the various levels of temperature and pressure that would be expected in a single planet in which equilibrium conditions were attained (*29, 30*) at a single high value at the center. Other evidence, such as variations in the metallic compositions of recovered iron meteorites, indicates their belonging to not less than two or three distinct groups (*31, 32*). Whether this means that they originated from the break-up of three or more bodies is problematical. It at least indicates that they probably did not result from the break-up of a single body, unless it is assumed that the metal became concentrated in several independent locations within that body. In any case, the mechanical strength of the various nickel-iron specimens, coupled with their irregular shapes, would indicate that in no case did the metallic meteorites exist as a solid central core in any cosmic body. They must have existed as small metallic concentrations intermingled with much stony material; otherwise they would exist in space only as very large bodies having a more or less spherical shape.

In the case of a planetary collision, depending on the relative velocities of the two bodies, we might have them smashed and the pieces sent flying off at various speeds in all directions. Some of the material might be expected to become diverted into hyperbolic paths and to leave our solar system forever. Other fragments, together with possible moons associated with the planets, would continue to circle the sun as meteors and asteroids in orbits of various sizes, eccentricities, and inclinations.

Whether the comets, which are known to be composed largely of frozen gaseous materials such as carbon, nitrogen, ammonia, carbon monoxide, and carbon dioxide were originally part of a colliding

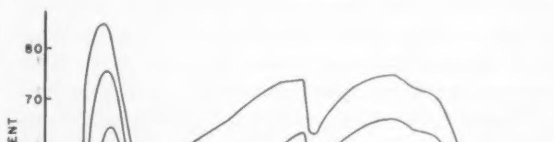

Fig. 5. Spectral infrared transmittances of five tektites from various sources. No. 8 is a moldavite; No. 6 is a Georgia tektite; Nos. 5*a* and 5*b* are Texas bediasites; No. 1 is a Philippine rizalite.

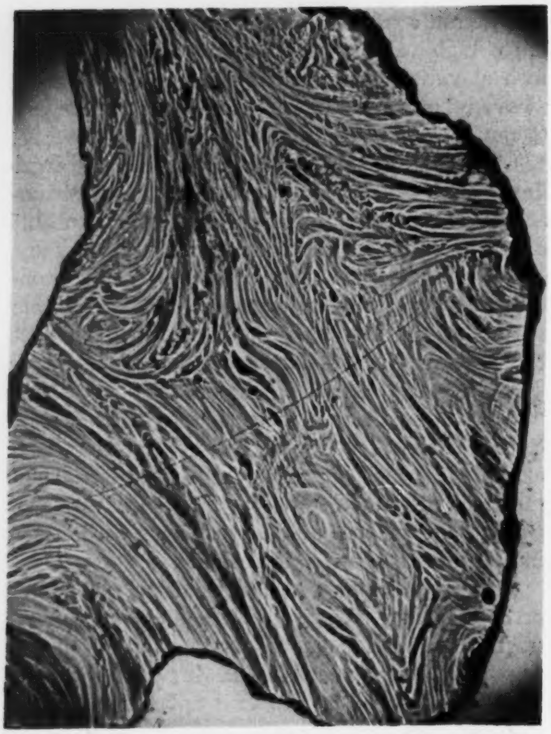

Fig. 6. Moldavite, illustrating the inhomogeneity of a thin polished section by means of transmitted light (×6.6).

planetoid or were independently formed is an unanswered question. There is considerable evidence that they are composed of solid fragments more or less held together by the frozen gaseous materials that vaporize and glow with a great brilliance when the comet reaches the vicinity of the sun. It has been suggested by Oort (*33*) that comets and meteors are the same type of object—the meteors being the debris of comets—and that both probably originated within the Mars-Jupiter region of the solar system. There is nothing in this reasoning to determine whether they originated as condensation (or accretion) products or as the result of some type of disruption. The present low gas density in the region of the solar system (even extending out to 50,000 to 200,000 A.U.) would certainly not permit their accumulation at this time along their present paths.

Each time a comet approaches the vicinity of the sun, a considerable amount of its frozen gaseous material is volatilized and swept off into space by the heat and pressure of the solar rays. If sufficient material is removed, the solid portions of the comet may fall apart, especially if the comet is shattered. Such seems to have been the case with a number of comets, in particular the brilliant comet of 1882, which left the region of the sun as four smaller comets.

From time to time, chunks of the shattered planet would be expected to (and do) collide with the earth, the moon, and presumably with the other planets and satellites of our solar system. The present orbits of the meteors, the comets, and the asteroids cannot be expected to give any reasonable indication of the original path of the parent planet. Although all the components may be assumed to have been at a single location within the solar system at the time of the collision, perturbations caused by Jupiter and the other bodies of the solar system have changed and rechanged their orbits so many times that about the only safe assumption to be made is that the original planet (or planets) was in an orbit of some shape between Mars and Jupiter.

Meteor Crater in Arizona is a good example of what happens when a meteorite composed of chunks of nickel-iron collides with the earth. The craters on the moon, visible through a small telescope, are a pictorial record of such collisions (*34*) through the ages. Not all the craters on the moon, however, should be credited to collision with fragments of the lost planet that is responsible for the meteors, comets, and part or all of the asteroids that are now a part of our solar family. Since the age tests on meteorites and tektites indicate that these objects have been subjected to the cosmic-ray intensity in our part of the milky way (our galaxy) for a period not exceeding a few hundred million years, as indicated in a previous paragraph, then only the newer craters—in general the smaller ones—could have been produced by this material. It is suggested that the larger lunar craters—which, incidentally, were made during the early history of the moon's formation nearly 4500 million years ago—must have been made by the impact of very large objects from some other source.

A possible and logical source of such objects could have been a family of small moons once circulating around our earth. Such a hypothesis seems reasonable from a number of points of view. Such small moons were not only possible, but many were actually formed in the condensation of the cosmic dust within our solar system. For example, one of the moons of Mars is barely 5 miles in diameter. Other moons are quite small. We do not know how many small ones may be circling some of the outer planets. There is ample reason to think that Jupiter may have lost a number of its moons because capture by the sun, or collisions, would be more probable in the case of the non-

retrograde traveling ones. On the other hand, if there should have been capture of moons, by Jupiter, from the material scattered in a planetary collision in the region between Mars and Jupiter, a retrograde direction of revolution would be expected to be more probable (*35*).

In the case of the earth's possible original system of moons, the capture of the smaller ones by our present satellite would account nicely for its giant size relative to that of the earth as compared with the sizes of other moons relative to their parent planets. Furthermore, little evidence exists to indicate that the earth suffered the extensive bombardment by large objects that the moon did at least during the last 100 million years since the time the meteoritic planet ended up in some sort of major catastrophe. However, since at that time the moon was apparently in a semiliquid state, the earth was probably still intensely hot; hence, any collisions with it would simply result in the addition of material that would be integrated throughout its structure. Hence, the old and very large craters on the moon (the seas) might indicate the accumulation of a vast number of planetoids (*14, 18*) by the earth in its early history. If such were the case, and it is highly possible and even probable, and since these could not have come from the lost planet, as indicated in a previous paragraph, their source must have been an early group of moons captured (by the sun) from Jupiter and the other planets, or else from a multitude of small planetoids that were once a part of our solar system and that might have been distributed with all sorts of orbital eccentricities more or less throughout its limits.

Flight of the Tektites

Now, how do we get the millions of small glass tektites from the debris of the lost meteoritic planet? Why not a few large chunks of glass? Glass is a fragile article, especially when it is not well annealed. It readily breaks from mechanical or thermal shock. Take, for example, a chunk of such material traveling at 40 to 50 miles per second, the usual speed of many meteors. When it hits the earth's atmosphere, an immense amount of heat is developed at its surface. The glass suffers a terrific thermal and mechanical shock. What happens? It necessarily flies apart and is scattered in many small pieces over a wide area, usually elliptical in shape. Urey has noted (*19*) that the break-up of a single piece of glass could not account for the wide distribution of the australites. Possibly the fall consisted of several original objects. Many questions

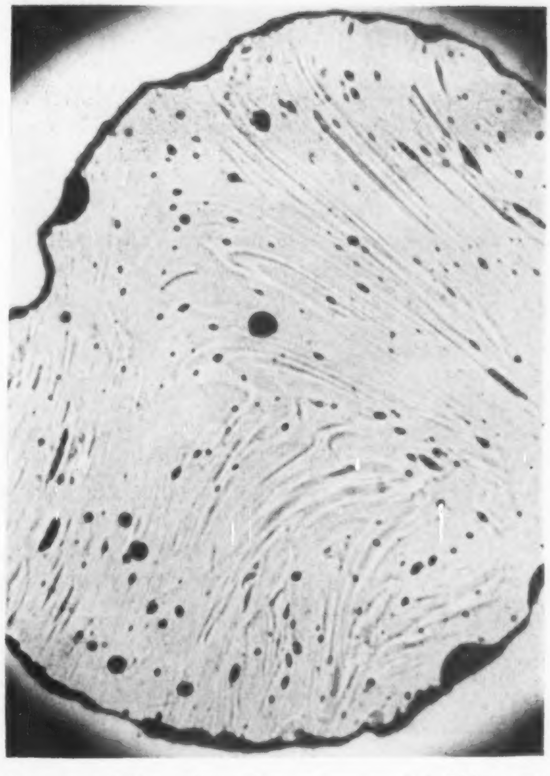

Fig. 7. Rizalite, illustrating presence of bubbles and marked inhomogeneities by means of transmitted light (×6.8).

concerning the origin of the tektites remain unanswered. The sizes of the many small pieces depend on the coefficient of expansion, the degree of annealing, and other physical properties of the material. Indeed, tektites having variations in composition are found to vary in size in general accordance with their physical characteristics. For example, Libyan Desert glass may be found in pieces up to 10 pounds, while a moldavite, having an intermediate coefficient of expansion, may weigh up to 1 or 2 pounds, but a tektite of relatively high temperature coefficient of expansion—for example an australite or rizalite—is found only in very small pieces that usually weigh not more than 1 or 2 ounces.

A study of other physical characteristics of the various tektites recovered also supports the aforementioned deductions. Striae, strain patterns, and inhomogeneities indicate that the small pieces were once a part of a larger body, for there is a lack of any appreciable distortion near the surfaces. Figures 6 to 9 show this characteristic of a number of the tektites. This rules out the formation of these glass specimens by a fusion of meteoritic materials

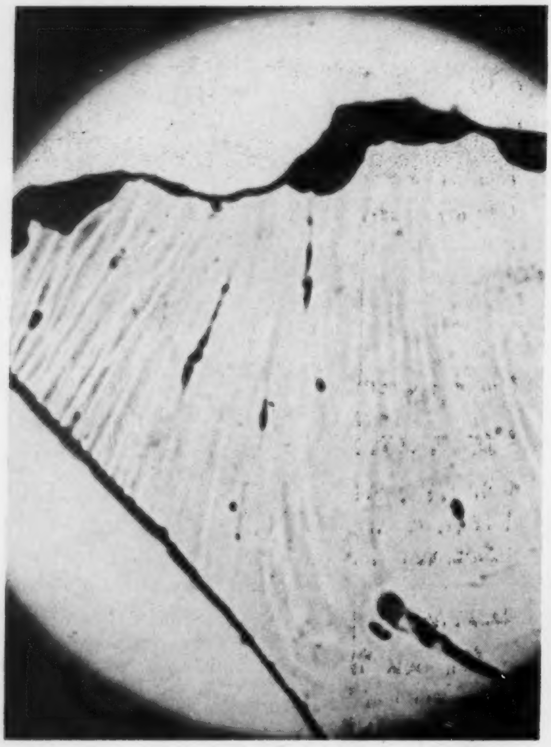

Fig. 8. Georgia tektite, illustrating the inhomogeneity of a thin polished section by means of transmitted light (× 5.2).

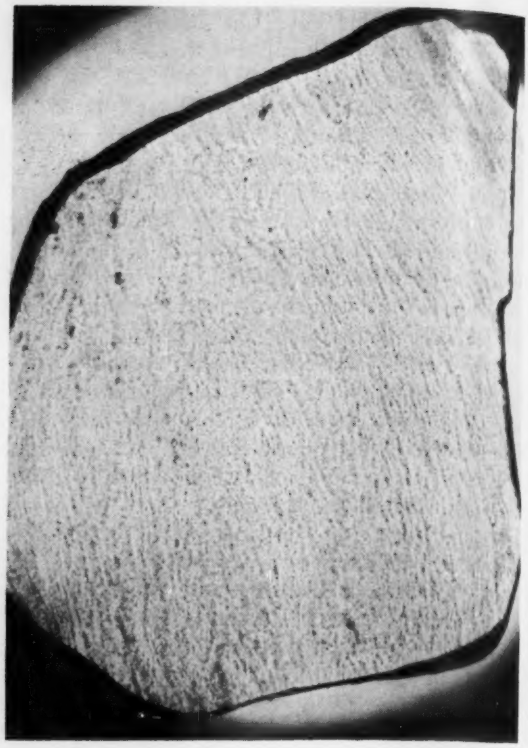

Fig. 9. Libyan Desert glass, showing internal structure of a thin polished section by means of transmitted light (× 7.6).

while they are passing near the sun in their orbits before they land on the earth. The time of flight through the earth's atmosphere is too short for the conduction of sufficient heat to melt or soften the specimen deeper than a surface film which, for the greater part, is swept away as it is formed. Only in the case of some of the australites (whose prehistoric fall was geologically recent) does any evidence remain to show the two distinct phases (*4*) in the formation of the glass specimen: (i) the central core of glass whose structure indicates a more or less annealed condition, which shows that the glass cooled slowly, and (ii) an outer surface having high strain and other characteristics indicative that the surface underwent softening at a later stage. All traces of double melting of all the other tektites, which fell during various earlier ages, have long since been eroded away. As noted, (see Fig. 1), an apron is often left on australite specimens that apparently did not rotate while they were in flight. Those that rotate may be expected to assume one of the natural forms such as spheres, ovals, buttons, dumbbells, and so forth, as the rough edges are smoothed in flight. Additional sculpturing effects, such as smooth lines and grooves, result from the removal of glass in an uneven manner, presumably in part by the particular aerodynamic forces that are brought into play when the object is traveling at such a high velocity, assisted by a more rapid melting of the softer striae within the glass, but later modified greatly by weathering and chemical reactions and resulting in the removal of quantities of glass where the more solvent material or other inhomogeneities occurred. Figures 10 to 12 illustrate beautifully the character of some of these surface features. Some of them are wormlike grooves and navels, often completely interlacing the surface of the specimen. This feature is more pronounced in some of the billitonites (Fig. 10), which have probably been buried in moist soil for a long time. When these billitonites are examined under low-power magnification (about × 10), numerous fine surface lines and figures, probably corresponding to the internal striae (Figs. 6 to 9) of the specimen, may be observed both on the outer surface and within the pittings.

It has been suggested that tektites may be glassy

material splashed from the moon (*5, 31, 36*) during the course of a meteoritic collision (and the resulting explosion). The splashing of the moon material cannot be denied, and some of it no doubt eventually reaches the earth, but it is thought that its composition, while probably glassy (*37*), could not possibly correspond to the near-perfect glass of tektites because of the lower temperatures under which the moon was formed. Urey inquires (*3*) whether very large objects having energies equivalent to millions of atomic bombs may have collided with the earth since Miocene times and have melted large quantities of terrestrial material, thus producing and scattering tektites over wide areas corresponding to the locations where they are found. Such an origin seems ruled out because existing tektite areas bear no relation to the location of known meteor craters and because it would not account for the surface flow on australite tektites or the character of the striae in any of them. Moreover, glass of this type could not result from a flash reaction for the reasons noted previously. It has been indicated by Suess (*24*) that large amounts of the silicon and aluminum oxides, and others of the constituents of the tektites, may have been expelled by some distillation process from the terrestrial planets and meteorites and have accumulated with the ices and frozen ammonia in the comets. As I have noted, when a comet approaches the sun large amounts of the ices and ammonia evaporate, leaving behind a luminous trail. In case the comet approached sufficiently close to the sun, the remaining matter could be expected to melt and form glassy solids (*38*) whose forms would be determined by their motion through the solar atmosphere. The interception of such a shower of material might therefore be a tektite fall, which, if intercepted by the earth on its exodus from the sun, might well account for their special distributions over the earth's surface. Furthermore, such an origin for tektites might well account for the low pressure of their gaseous contents (*24*).

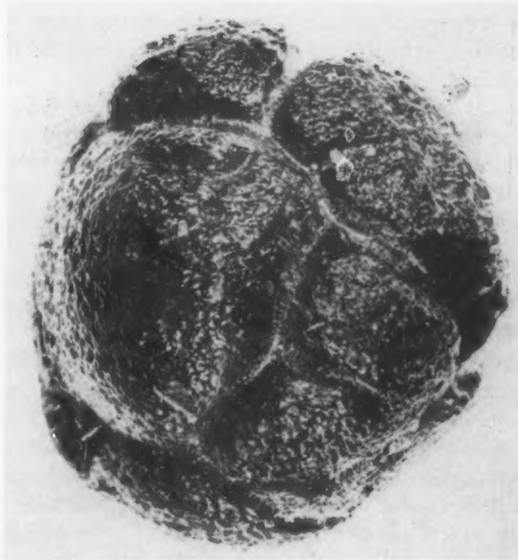

Fig. 11. Tektite from Paracale Bay, Philippines, illustrating surface features often found on tektites recovered within that area. [Courtesy E. P. Henderson, National Museum]

Fig. 10. Billitonites from the island of Billiton, illustrating the wormlike grooves and navels resulting principally from chemical corrosion through being buried in moist soil for many years. [Courtesy E. P. Henderson, National Museum]

Key to Cosmological Problems

Scientific study of the tektite glasses has been somewhat neglected in meteoritic investigations, principally because it was only recently that their true origin had been established. It was long contended that, because the glass tektites were so far removed from other meteorites in composition, they could not be of the same origin. However, since their durability greatly exceeds that of the softer glasses and since their geologic associations indicate that they have landed on the earth in showers during the past 50 million years (neither tektites nor other meteorites have been found in any of the ancient geologic formations), it appears reasonable to assume that only the more durable types of glass could have survived the weathering

of the ages. Such an assumption would allow the existence of all types of glassy meteorites from the tektites to ordinary stony ones containing only traces of glass. It might also have a bearing on the abundance of tektite material relative to that of other meteorites, which, within certain areas, exceeds in tonnage that of all other types combined.

The complicated structure of tektite glasses still holds many of the secrets relating to their formation in the parent lost planet. Therefore, the study of their physical and chemical characteristics, together with research in the production of similar glasses, should furnish valuable information and thus become the key (the Rosetta stone) (*29*) to the solution of some of the cosmological problems facing the astronomers, geologists, and meteoriticists today by adding not only to our knowledge of the origin of these glassy meteorites but to a better understanding of the formation of the solar system—yes, even of the universe itself.

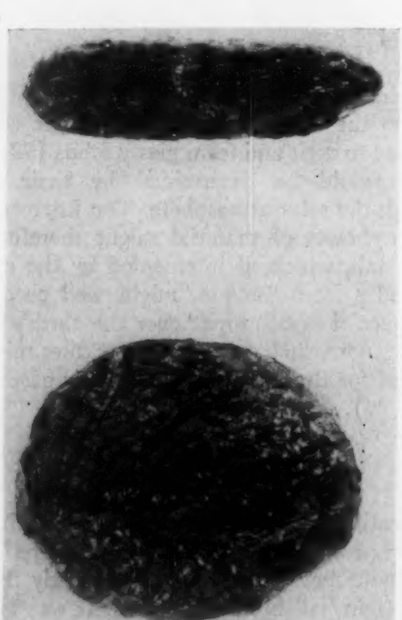

Fig. 12. American tektites. Smaller specimen from near Delhi, Beckman County, Okla.; larger specimens from Empire, Ga. (×1.5) [Courtesy E. P. Henderson, National Museum]

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In an oration a man does better to show his affection than his judgment: that is, 'tis better to say, "I like this" than to say, "This is better." For by the one you would seem wise, by the other good. But favour follows goodness; whereas wisdom procures envy.—ARISTOTLE, *Of the Narration.*

International Geophysical Year Earth Satellite Program

HOMER E. NEWELL, JR.

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SOME time in the next several years a new object will appear in the heavens. Unlike the fixed stars, the newcomer will move rapidly across the sky. It will, however, be visible to the naked eye only at certain favorable times, and then only to the observer who knows exactly where to look for it. It will be very inconspicuous, yet its appearance in the sky will be an exciting and historically significant event, for it will mark the opening of the space frontier.

Plans of the U.S. National Committee for the International Geophysical Year to launch artificial earth satellites during the International Geophysical Year were announced 29 July 1955. These man-made moons will be used for geophysical and solar research. They will be unclassified, and the data obtained from them will be published in the open literature. More than that, the nations active in the IGY program have been invited to participate in the use of the satellites, and to this end the necessary information on their instrumentation and orbits will be made available. The projected satellite program is a constructive endeavor on an international scale; it is directed toward expanding man's knowledge of the universe about him.

The launching of an artificial earth satellite has important social implications. As a first, even though small, step toward manned space flight, it heralds the eventual breaking of the chains that bind man to earth. From time immemorial, intrepid adventurers have sought out the remote and inaccessible. Men have long dreamed, talked, and written about visits to the realms of outer space. For example, in 1865 Jules Verne wrote of a trip to the moon, and with increasing frequency during the last several decades the world has heard talk of trips not only to the moon but to the planets as well. The discussion has varied all the way from wild over-imaginative fantasy to sober scientific analysis of the problems involved.

Large-Scale Program

Small wonder, then, that the proposed satellite program should generate widespread excitement and assume a glamor all its own. Nevertheless, it is well to remember that the satellite studies will be only a part of a much larger research program. The International Geophysical Year, scheduled for the period from 1 July 1957 to 31 December 1958, will be a concerted attack by some 40 nations on important problems of the earth sciences and solar physics. Previous similar efforts took place during the Polar years of 1882 and 1932, but they were of limited scope in comparison with the present program. During the IGY, the globe will be girdled with hundreds of observing stations. Closely integrated networks will cover areas of special activity and importance such as the auroral zones and the Antarctic. In fact, the assault on the Antarctic region will feature more than three dozen stations on and around the continent, with one at the very pole.

Chief among the IGY studies will be those that require a world-wide, cooperative, or synoptic approach. The opportunity will also be taken to accelerate researches that otherwise might spread out over many years or decades. Still other investigations will have places in the over-all program to take advantage of the increase in research and observational facilities. Meteorology, ionospheric physics, aurora and airglow, solar activity, cosmic rays, geomagnetism, latitude and longitude, oceanography, glaciology, gravity, and seismology are all on the IGY roster.

A significant part of the IGY effort will be concerned with the upper atmosphere and solar-terrestrial relationships, for the study of which a powerful new tool has appeared since the Polar Year of 1932. This new tool is the high-altitude rocket, which makes possible many observations

that are not possible from the ground. The rocket also provides a means of checking by direct observation measurements made indirectly from stations at or near the surface of the earth. One can, therefore, use the rocket to calibrate ground-based techniques with which one can then carry out observations more extensively timewise and geographically than would be practical with rockets alone.

The power of the new technique quickly won for rocket sounding a prominent place in IGY planning. The United States will fire literally hundreds of research missiles during the IGY, ranging from the relatively small balloon- or aircraft-launched vehicles through multi-stage, solid-propellant combinations to high-performance Aerobees that are capable of reaching altitudes of 200 miles. Firing locations will range from the Arctic to the Antarctic. It is understood that other countries also, such as France, England, Australia, and Japan, will undertake programs of rocket sounding during the IGY.

A program confined to vertical rocket soundings is, however, incomplete. Fired in the usual steep trajectory, a research missile rises to peak altitude in a few minutes, and then as quickly returns to the earth. Such a vehicle provides a means of obtaining a vertical picture of the atmosphere at essentially a single instant of time. At the peak of the flight the scientist is permitted but a brief glimpse of conditions above the atmosphere. Yet there are many important observations to make above the atmosphere over extended periods of time. Studies of the fluctuations in cosmic rays and those solar radiations that are absorbed by the atmosphere are illustrations. For such studies, one needs an instrument platform that remains at high altitude. An earth satellite would provide such a platform.

Early Plans

The usefulness of an artificial satellite for research purposes has long been recognized. In fact, at the very beginning of its rocket sounding program in 1946, the Naval Research Laboratory, looking toward the future, made a study of the problems involved in creating and using an artificial satellite for geophysical and solar research. It can be assumed that other agencies did likewise. With continuing improvement in rocket performance and missile techniques, the means for launching a satellite have been developed. Various authors have outlined and published plans and recommendations for specific satellite projects. The American Rocket Society made a limited study of the usefulness of an earth satellite and submitted it to the National Science Foundation with a recommendation that a more thorough analysis be undertaken. At the international meetings during the summer and fall of 1954, the International Union of Scientific Radio, the International Union of Geodesy and Geophysics, and the Special Committee for the IGY all pointed to the usefulness of artificial satellites for scientific research, and recommended that consideration be given to their employment during the IGY.

Out of all this activity, and on the basis of careful studies made by its advisers, the U.S. National Committee for the IGY recommended the creation of an artificial satellite program to the U.S. Government. The outcome of that recommendation is now known to all.

Lack of specific details on the announced satellite program invites speculation, and this is what is proposed for the following paragraphs. The reader is invited to consider some of the problems that face the program planners. It should be emphasized, however, that the following is not a description of actual plans, but simply a review of possibilities.

An Artificial Moon

Before taking up some of the technical problems that are involved in creating an artificial satellite, it might be well to consider just what an artificial satellite is. The proposed satellite has often been referred to as an artificial moon, and that is just what it is. Like the natural moon, it will revolve about the earth in some orbit, staying aloft because of the energy that is imparted to it during the launching operations. One can get some idea of how this comes about by performing the following mental experiment. Suppose that an object has been lifted to a height of 200 or 300 miles. If it were simply dropped from such a height, the object would fall straight to the ground. If the earth were a perfect sphere and if it were not rotating, the body would move along a straight line toward the center of the earth and would strike the ground directly below the release point. Now if the object were given a sidewise nudge just as it was dropped, then the impact point on the ground would also be displaced to one side. The greater the sideways shove at release, the farther around the earth the object would strike the ground. In fact, pursuing this thought further, one can easily imagine that exactly the right horizontal shove would cause the impact point to be on the opposite side of the earth from the release point, while an even greater horizontal push would cause the body to miss the

earth completely. In the latter case, the object would simply keep on encircling the earth as an artificial satellite.

One can picture this process somewhat as follows. An object released at high altitude will always be falling in accordance with the acceleration of gravity. But if the object is released with enough horizontal velocity, it will always "sidestep," so to speak, fast enough so that it never falls to the ground. The problem of creating an artificial satellite is one of lifting an object to orbital altitude and then projecting it horizontally at sufficient velocity to cause it to revolve around the earth as the moon does. The means for accomplishing this are to be found in the large modern rockets.

If the earth were a perfect sphere with no atmosphere, an artificial satellite would revolve about it in a circle, an ellipse, a parabola, or a hyperbola. Such a body would be moving in a parabolic orbit when it had just the right velocity to escape completely from the earth's gravitational field, and in a hyperbolic orbit when it had greater velocity than that required for escape. At the surface of the earth, the escape velocity is about 7 miles per second. When it was not moving fast enough to escape, the satellite would travel in a circular or an elliptical orbit.

A principal characteristic of a circular orbit is that the centrifugal force on the satellite due to its motion always exactly balances that due to gravity. The center of the orbit coincides with that of the earth; hence, the satellite's velocity vector is always normal to the radius from the center of the earth. At any point in space, the corresponding circular-orbital velocity is always just $1/\sqrt{2}$ times the parabolic or escape velocity for that location.

When the satellite moves in an elliptical orbit, one of the foci of the orbit coincides with the center of the earth. Thus the distance of the satellite from the earth's center varies with time between a nearest point, called perigee, and a farthest point, called apogee. Only at perigee and apogee does the satellite move normally to the radius vector from the center of the earth.

Suppose that a satellite vehicle has been lifted by a rocket to orbital altitude and is about to be projected into its orbit. If the vehicle is launched precisely horizontally and with precisely the circular velocity, then the satellite will revolve in a circular orbit. But if either or both these criteria are not met, the orbit will not be a circle. If the satellite is projected precisely horizontally, but at less than the circular velocity, then the launching point will be apogee, and perigee will occur halfway around the earth—unless, of course, the velocity of projection is so slow that the orbit passes through the earth itself, in which case the satellite will strike the ground. Projecting the vehicle precisely horizontally but with more than the circular velocity will cause the launching point to be perigee. In this case, if the velocity of projection is less than the escape velocity, apogee will be halfway around the earth from the launching point. If the satellite is projected at the escape velocity or greater, it will leave the vicinity of the earth never to return.

Whenever the satellite is projected into its orbit at an angle different from the horizontal, then perigee is always nearer the earth than the launching point, and apogee is always further away. When it is projected downward, the satellite will pass through perigee before reaching apogee, and vice versa when it is projected upward. In either case, if the angle with the horizon is too great, the satellite will eventually strike the earth, thereby terminating its flight, unless it happens to be projected upward with escape speed or greater.

Two factors will modify the behavior of an artificial earth satellite. These are the oblateness of the earth and the resistance of the atmosphere to the satellite's motion. As is well known, the centrifugal force due to the earth's rotation causes a bulge at the equator, making the radius at the poles some 13 miles shorter than that at the equator. If the satellite's orbit is inclined to the equator of the earth, then the excess mass in the bulge tends to pull the satellite out of the plane of its orbit. The result is to cause the plane of the orbit to rotate in space with a rate of rotation inversely proportional to the cosine of the angle of inclination of the orbit to the equator. The limiting period of this turning of the orbital plane as the angle of inclination vanishes is about 1½ months. The bulge also tends to speed up the satellite in its path as it approaches the equator, and this causes the positions of apogee and perigee to slide around the orbit. All this is even further complicated for an observer on the ground by the additional apparent motions of the satellite that are caused by the rotation of the earth.

Finally, the resistance of the earth's atmosphere to the satellite's motion through it continually removes energy from the vehicle, causing the orbit to degenerate steadily. Eventually this process will cause the satellite to spiral into the lower atmosphere and be destroyed. Some idea of the magnitude of this effect can be obtained by using values for upper air densities that are indicated in conventional rocket results. With these, E. Pressly has shown that a satellite of mass in grams equal to its cross-section in square centimeters would not even orbit once if it were launched horizontally with

circular velocity at an altitude of 100 miles, would remain aloft for roughly 15 days if it were so launched at 200 miles, and would last almost a year if it were so launched at 300 miles.

Technical Problems

One is now in a position to appreciate some of the problems that face the creators of an artificial satellite. First, the satellite must be lifted to a point above the appreciable atmosphere, which means to an altitude at or above 200 miles. Then it must be projected as nearly horizontally as guidance accuracy will permit, and with sufficient velocity to insure that the vehicle will remain above the appreciable atmosphere throughout its orbit. By designing the propulsion system to give with certainty more than enough velocity, one factor can easily be taken care of. However, the guidance problem is more difficult. If, for launching with circular velocity at altitudes in the range from 200 to 300 miles, the angle of projection misses the true horizontal by as much as 2°, the perigee altitude will be roughly half the launching height. Such an error occurring with a launching altitude of 200 miles or less would cause the satellite to dip well into the denser parts of the atmosphere and would, accordingly, cut short its lifetime. Thus, for launchings between 200 and 300 miles, which are the altitudes likely in the early experiments, the engineer will seek a guidance accuracy as much better than $\pm 2°$ error as possible.

If the launching direction of the vehicle misses in azimuth, the consequences are not as serious as far as satellite lifetime is concerned. But then another problem presents itself—that of locating observing stations on the ground. As will be brought out in subsequent paragraphs, different orbits will be desired for different experiments. These orbits may be classed roughly into three different types: equatorial, polar, and intermediate. For the first case, the satellite moves around the equatorial plane, always above the equator, and the earth's rotation simply causes a change in the apparent time of revolution. The placement of observing stations on the ground is especially simple in this case. In the polar orbit, however, the rotation of the earth causes the track of the satellite over the ground to spiral around in a complicated fashion. Only at the poles can one always count on a passage of the satellite overhead once per revolution. It is plain that the location of observing stations for a polar orbit presents some great difficulties. For the intermediate orbit, the track of the satellite over the ground will wind around in a sort of sine wave between a maximum latitude north and an equal maximum latitude south. The equatorial crossing points, or nodes, will move around the equator in a fashion that depends mainly on the earth's rotation, but also somewhat on the rotation of the orbital plane caused by the earth's oblateness. It is plain that in the intermediate case also the setting up of ground stations will be troublesome, the difficulty in general becoming more pronounced as the inclination of the orbit to the equator increases.

It is convenient in discussing the artificial satellite project to speak of two systems. The first may be termed the propulsion system. Actually, it will consist of considerably more than just the rockets needed to boost the satellite to orbital altitude and speed. As must be plain from the preceding discussion, accurate guidance and control will be required, and this implies an extensive tracking and computational set-up on the ground, in addition to launching equipment. The purpose of the first system will be to create the satellite according to the various orbital and other requirements of the experiments to be performed and to provide the initial infomation on exactly what orbit the vehicle did take.

The second system may well be called the satellite system. It includes the orbiting vehicle with its instrumentation, plus whatever tracking, telemetering, and computing stations are needed on the ground to perform the intended experiments.

Though they may be separated easily in purpose and concept, the propulsion and satellite systems will necessarily react upon each other in practice. To be useful, the satellite must satisfy certain minimum requirements of weight, size, and orbit. On the other hand, any propulsion system that might be devised will have a certain maximum capability that depends on the present state of advancement in propulsion and guidance techniques. From the announcement of plans to create an artificial satellite in the near future, one may conclude that IGY planners consider that the areas of usefulness and present feasibility overlap.

Uses

The possible uses of an artificial earth satellite as a platform for scientific research are many. By letting the imagination roam, one can devise significant experiments in a wide variety of geophysical, astrophysical, and cosmic problems. Among such experiments, the more elaborate ones would be beyond the capabilities of the first satellites. The performance of such experiments will have to be postponed until the future, when advancing propulsion and instrumentation techniques will make

them possible. But there are also important observations and measurements that can be made with satellites of modest proportions and with instrumentation that is already available.

Even a vehicle without instruments can be useful. If its orbit can be accurately determined, the satellite can be used as the moon is used for geodetic measurements. Observations made of the artificial moon at different spots on the earth, either simultaneously or at precisely related times, can be used to determine the distance on the ground between the observing sites. In addition, by measuring the effect of the earth's oblateness on a satellite moving in an orbit inclined to the equator, it should be possible to determine the actual amount of bulging at the equator. It may be, too, that nonuniformity in the distribution of mass in the earth's crust will cause an observable perturbation in the orbit, but in any case the effect will be much smaller than that caused by the earth's oblateness.

It is thought by many that the satellite will permit an appreciable improvement in the accuracy of geodetic measurements over what is now obtainable from observations on the moon. Whether or not this is true remains to be seen. It is certain, however, that the use of the artificial satellite as a geodetic aid involves problems of far greater difficulty than the simple statement of the application can convey. Of primary importance will be the precise determination of the orbit and the prediction of the satellite's position as a function of time, so that the various observers may know where to look for it and will be able to relate their separate observations very accurately in time. This implies the need for highly accurate tracking at the time of and immediately following its launching, as well as a need for high-speed computational facilities to take this early tracking data and quickly determine the orbit. With this computed orbit, other tracking stations along the vehicle's track may be directed toward the satellite, and the initial equipment can be set to pick it up again upon its return. Without the computed orbit, the satellite may well be lost to the observers on the ground, and an unobserved satellite would be quite useless. An additional complication in this whole process will be the fact that already existing errors in geodetic measurements must necessarily appear in the original determination of the satellite's orbit, yet it is this very orbit that will be used for improving currently available measurements of the earth's size and shape. One is forced to conclude that a series of successive approximations will be required to arrive at the improved values that are sought.

From any improvement in geodetic measurements that might be obtained from the artificial satellite, there would accrue practical benefits in the betterment of navigation and mapping.

The effect of air resistance on the satellite will make its use as a geodetic aid all the more difficult. Thus, for this purpose, the vehicle should be launched high enough to make the air drag negligible over a large number of revolutions. In this case, an orbit with perigee at an altitude of no less than 300 miles appears to be called for.

On the other hand, the effect of drag on the vehicle can be used to determine the air density ρ at orbital altitude. The air drag is proportional to the square of the vehicle's speed and to ρ, where the factor of proportionality involves the geometry of the vehicle and can in large measure be controlled. Thus, by observing the motion of the satellite, one can obtain ρ. Here again the problem is much more easily stated than solved. To sift the values of ρ out of the observed data will require much difficult computation, but it should be possible.

One of the most interesting features of the two applications of artificial satellites discussed here is the fact that they require simply tracking of the vehicle. This makes possible a joint venture among the nations that will be in a position to observe the object. As pointed out already, an orbit intermediate between a polar and an equatorial one is desirable to permit study of perturbations caused by the oblateness of the earth. Such an orbit would admit of extensive international participation, possibly allowing the use of observing centers that are already in existence. It is planned to make known the intended orbits of vehicles launched during the IGY and to arrange for communicating the calculated data on the actual orbit to those who will be in a position to observe the satellite and who desire to do so.

Instrumentation

The next step in the use of an artificial satellite for research is to make the vehicle "active"—that is, to install instruments that will transmit their measurements to the earth by radio. In this case, a premium is placed on weight and in particular on the weight that can be devoted to an energy supply for powering the instruments and telemetering transmitters. A sound approach to the instrumentation problem is to use insofar as possible techniques that have already been developed for conventional rocket research. In the outfitting of small rockets, especially, we have learned how to do an appreciable amount of experimenting with payloads of only 20 or 30 pounds. Of course, the power supply problem in rockets is not so difficult,

for the total observation time is only a matter of minutes. In the satellite, however, a primary feature for exploitation is the long stay outside the atmosphere. For this reason, we will want to refine the sensing elements, their circuitry, and the telemeter packaging as much as possible in mass and in volume in order that the maximum amount of the payload may be in the form of energy supply for running the equipment. In the early experiments, it may be presumed that power supplies will consist of conventional batteries made of such elements as Silvercels or mercury cells. Hence continuous operation of instruments throughout the entire lifetime of the satellite will not be possible. It will be necessary, therefore, to operate the equipment only during certain intervals. In particular, the transmitter would be turned on only when the vehicle was in view of the telemetering ground station.

To turn on the equipment in the satellite at the desired time will be a problem. At first thought, one might consider some low-power timer within the vehicle. But to arrange to synchronize the timer with the motion of the satellite in such a way that the equipment is turned on at just the moment that the satellite is observed at a given spot is virtually impossible, particularly since the vehicle will be observed for only a matter of minutes at each passage, the times of which will be greatly affected by launching errors. The equipment will probably have to be turned on from the ground, with a signal from a radar, say, to a low-power standby detector that will activate a relay. At the same time, a mechanical timer can be activated to turn off the equipment after a suitable number of minutes.

Future development of means of using solar energy for powering the satellite equipment, such as with thermocouples or with the boron-silicon strips devised by Bell Telephone Laboratories, should greatly simplify the energy-supply problem. However, there is probably too much engineering still required along these lines to count on the use of such solar batteries for the IGY satellite experiments.

Among the possible satellite experiments that can be performed with known rocket techniques, we may list the study of cosmic rays, measurement of the earth's magnetic field, observation of solar ultraviolet light and x-rays, and possibly the detection of meteorites and particles in interplanetary space. Because of experience in conventional rockets with the instruments that are required, we can feel confident of being able to design for any one of the studies mentioned a complete installation that weighs between 20 and 30 pounds and that is capable of fitting into the restricted space afforded by a small satellite vehicle.

Along with the instruments for measuring the parameter under study, such a complete instrumentation would include such things as a telemetering transmitter, equipment for detecting the satellite's orientation in space, a control receiver and timing mechanism for turning the equipment on and off, and an energy supply. Each installation would be tailor-made to the requirements of the experiment and the limitations of the vehicle; hence the total operating time would vary from case to case. As a rough idea, however, a fairly substantial experiment could be carried out with power consumption of 50 watts during total operation of say 3 minutes each revolution, and 1 watt in standby condition. It should be possible to design into the early small vehicles upward of 500 watt-hours of energy supply. This would then permit measurement for at least 125 revolutions, which corresponds to slightly less than 8 days. Almost two-fifths of the energy consumption in the example given occurs during standby condition, even though the power required is low. This is, of course, the result of the fact that the equipment is in standby condition so much longer than it is in total operating condition; this is a factor to remember when considering the use of recorders to collect data continuously for coding and transmission during the few minutes of radio contact with the ground. The power consumption of the recorders would greatly reduce the number of revolutions over which the satellite would remain active, although in many cases the gains might be worth the penalty.

Cosmic rays could be studied in satellites with Geiger counter installations, just as they have been studied in balloons and conventional rockets. As is now known, cosmic rays are composed of very high-energy, charged particles, roughly 80 percent protons and 18 or 19 percent alpha particles, the remainder being heavier nuclei. Being charged, the cosmic-ray particles that move across the lines of force of the earth's magnetic field are deflected, and those of too-low an energy do not reach the earth at all. Thus, cosmic rays experience a maximum deflecting effect at the equator, where the magnetic field lines are horizontal, and a decreasing effect with increasing geomagnetic latitude. Were it not for the atmosphere, the very lowest energy particles would penetrate to the earth's surface at the geomagnetic poles. It is, however, necessary to be above the atmosphere to observe these low-energy particles. Thus, a satellite vehicle that moves in a polar orbit at an altitude of 200 to 300 miles would permit observations of the very lowest energy rays. The approach to continuous observation would permit study of fluctuations in cosmic-ray intensity that have been noted in con-

junction with magnetic and solar activity. Being above the atmosphere will be of considerable advantage here, for these effects are often most prominent in the low-energy end of the spectrum. In the polar orbit, the magnetic field effect would help the observer to sort out the rays into different energy groups, as is done in balloon and conventional rocket experiments by making observations at different geomagnetic latitudes. However, the polar orbit would make the layout of ground stations extremely difficult, as pointed out in a previous paragraph.

Since cosmic rays involve the highest energy particles known, their study is of great interest to the scientist. The mystery of their origin is yet to be solved and is thought to be linked with some of the most fundamental aspects of physics and the universe. From a practical point of view, cosmic rays interest the promoters of space flight, for they constitute a potential hazard. It is now generally believed that this hazard is not serious, but whatever additional data can be provided for judging the danger is certainly desirable. Since a major part of whatever danger that does exist lies in the highly ionizing heavy particles, which do not penetrate the atmosphere, the satellite observations can make an obvious contribution.

As the source of most of the energy affecting the earth and its atmosphere, sunlight is of prime interest and importance. The wavelengths in the ultraviolet and x-ray regions are absorbed at high altitudes, causing photochemical activity, the ionosphere, heating, and winds. Variations in intensity of solar radiations are felt in corresponding variations of atmospheric and weather phenomena. During the IGY, when sunspot maximum will occur, solar activity will be enhanced, providing especially favorable conditions for studying solar-terrestrial relationships.

With photon counters in a satellite vehicle, the ultraviolet regions of the solar spectrum can be monitored above the absorbing atmosphere. In particular, the opportunity will exist to observe the ultraviolet light curve of the sun during the occurrence of solar flares. The particular orbit followed by the vehicle will be of no consequence as far as the observations are concerned; hence the orbit can be chosen to simplify as much as possible the logistics involved in the launching and in the establishment of observing stations. For this type of study, the polar orbit would doubtless be avoided.

From a practical point of view, solar radiation studies would contribute to a better understanding of the ionosphere and of weather and climate. The ionosphere is intimately linked with radio communications, and advancing knowledge about the ionosphere is bound to be profitable. The practical importance of improved knowledge about weather and climate is obvious.

Other Satellite Experiments

J. H. Heppner has proposed the measuring of the earth's magnetic field above the E-region of the ionosphere as a possible satellite experiment. A small but very interesting part of the earth's magnetic field is caused by current systems in the ionosphere and in outer space. The fluctuations of the current systems are believed to cause corresponding fluctuations that are observed in the earth's magnetic field at the ground. A current sheet in the neighborhood of 100 kilometers, in the E-region, has already been detected in an Aerobee experiment. By satellite measurements, it is proposed to detect the presence of additional currents in what is called the Chapman-Störmer current ring.

The Chapman-Störmer current ring is supposed to encircle the earth in an equatorial belt at several earth radii from the surface of the earth. It is composed of charged particles that the earth's permanent magnetism has deflected into a ring from streams issuing from the sun. As the supply of particles from the sun varies, so does the effect of the ring on the surface magnetic field. The sudden appearance of an intense stream of solar particles produces a pronounced variation in the earth's magnetic field. In addition, one theory has it that particles spraying off the Chapman-Störmer ring reach the earth's atmosphere in the auroral zones and cause the aurora.

Heppner's experiment consists in making continuous satellite measurements of the earth's magnetic field at an altitude of 200 or 300 miles while simultaneous measurements of the magnetic field are made at the ground. With the high altitude and ground curves, it should then be possible to estimate the magnitude of current in the Chapman-Störmer ring. For the accomplishment of the proposed satellite measurements, there already exists a lightweight version of a proton-precession magnetometer, designed for small rocket experiments, that will give the total field. In addition, H. Caulk and his coworkers have modified a magnetic pickup tube into an extremely lightweight device for measuring a single field component.

Because they are closely associated with radio blackouts, magnetic storms and the aurora are certainly of interest to the practical man. It may be expected that satellite experiments such as those I have described will in the long run contribute to more efficient use of the periods when radio communications are possible.

Interplanetary space is not completely a vacuum. Its actual population, however, is not definitely known, although for a long time now the figure of one atom per cubic centimeter has been used. The data on which this estimate is based are meager, and to provide a better estimate, H. Friedman and his coworkers have proposed a fascinating satellite experiment. Their proposal is to observe the sun directly in the Lyman α-region (1216 A) by means of photon counters, and simultaneously to observe the Lyman α-radiation emanating from some direction other than that of the sun. By correlating the intensities observed directly from the sun with those observed off at an angle, it should be possible to estimate the average density in space of hydrogen atoms and ions. Also, marked variations that are above the general average observed might be attributed to solar proton streams.

Just as we have been interested in the earth's atmosphere as the window through which we look into interplanetary space, so these measurements concern the interplanetary atmosphere that comprises the window to interstellar space. To the practical man, the study of proton streams is linked with the Chapman-Störmer current rings and the aurora, the importance of which to the problem of radio communications has been pointed out.

Small meteoritic particles, a few thousandths of an inch in diameter, are constantly impinging on the earth's atmosphere. Although the particles doubtless enter with great speed, the impacts with the molecules of air soon slow them down, and then they drift to the ground. Estimates about the quantity reaching the earth's surface vary—some are as high as 1000 tons per day for the whole earth. These micrometeorites, as they are called, are believed to contribute a measurable, though small, amount to the ionizing of the atmosphere in the E-region. What these particles may mean to the practical man is difficult to say, but they may some day concern the designer of space stations and space vehicles.

With the use of simple impact detectors and electrostatic analyzers, these micrometeorites can be observed. For the impact detectors, resistance plates or scintillation counters with photocells can be used.

Conclusion

The foregoing are some of the experiments that could be performed in the early satellite vehicles using techniques that are already available. The sort of experiment considered, which is simple and conservative of weight, and which does not require extremely difficult engineering and operational feats for its accomplishment, is the type that should be considered for the first satellite project. Television, telescopes, radio relays, photography, and in fact anything that requires recovery of equipment or material from the vehicle are definitely for the future. The first three items listed will require too much payload weight for the complicated equipment and large amount of energy needed to be attempted in the early experiments. Photographs of the earth would involve the exceedingly difficult problems of getting the satellite back to earth safely and then finding it to retrieve the film.

Finally, manned space stations and manned space flights are for the quite distant future. The single matter of having to achieve perfect reliability in every component used, and throughout the entire system that links the components together, raises the difficulties by many orders of magnitude above those involved in unmanned flight, in which for each attempt probabilities of success that are appreciably less than certainty are economically acceptable. In addition, the payload required for carrying not only the man but also the equipment he would need for survival would demand far more of a propulsion system than a simple artificial satellite experiment does.

To be useful, an artificial satellite must be observed, either optically or otherwise. To launch an unobservable object into an orbit would be simply a stunt, hardly to be classed as a worthwhile scientific endeavor. Also, a satellite must be launched above the appreciable atmosphere, or else air resistance will quickly destroy it. One may reasonably translate this into the requirement that the vehicle be made to orbit at or above 200 miles. In such a case, then, it is difficult to see how a satellite of mass of the order of 1 pound could be useful. One weighing on the order of 10 pounds, however, could be made observable. As R. Tousey has shown, a 20-inch sphere orbiting at an altitude of 200 or 300 miles could be seen optically at certain favorable times after sunset and before sunrise. A satellite of this size could then be considered useful. However, such a satellite might not be one of those I have described as "active," whereas many of the valuable experiments discussed require an active vehicle. In fact, for such an active vehicle, a reasonable minimum would seem to be those payloads that have been used in balloon-launched rocket experiments.

The foregoing discussion has taken up some general aspects of the problems involved in creating an artificial satellite of the earth, and it has reviewed some of the uses to which such a satellite

might be put. The Department of Defense will carry out the launching of IGY satellites, and the U.S. National Committee for the IGY will oversee the geophysical experimentation. The actual experiments to be performed have not yet been announced. It would seem reasonable to assume, however, that early satellite experiments will be of modest proportions such as some of those I have described. In the future, as both rocket and instrumental techniques improve and advance, more difficult observations will become possible.

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Man-Made Diamonds

The cover this month is a photograph of a cluster of man-made diamonds that were produced at the General Electric Research Laboratory in Schenectady, New York. In February 1955, General Electric announced the achievement of synthetic diamonds after 4 years of intensive work with high temperatures and high pressures on different materials. In May of this year, General Electric presented a cluster of their first synthetic diamonds to the Smithsonian Institution in Washington, D.C., and announced that synthetic industrial diamonds are now being produced in limited quantities at the Detroit pilot plant of G.E.'s Carboloy Department. In a radio address in late December 1955, C. Guy Suits, vice president and director of research for General Electric made the following remarks.

"The diamond process is readily reproducible and can be repeated as often as desired, always producing diamonds. This process takes place at pressures which are hard to conceive of—over a million pounds per square inch. Recently we have been able to work at still higher pressures.

"The significance of this achievement is two-fold. First, its technological significance lies in the industrial importance of diamond. Over 90 percent (on a weight basis) of diamonds imported into the U.S. are industrial stones. They are used for industrial grinding, cutting, and polishing operations involved in the working of hard materials—metals, alloys, ceramics, and glass. If man-made diamonds can be mass-produced at a satisfactory price, American industry will be liberated from dependence upon imports of a critical material, the supply and price of which are controlled by foreign interests.

"Second, the scientific importance of man-made diamonds lies in the fact that the information and techniques developed in this research have opened new doors to nature's storehouse and revealed challenging new possibilities. It is entirely conceivable that further exploration in this hitherto inaccessible domain of super-temperature and super-pressure will yield results of even greater value than the ability to make diamond."

Some Notes on the Ecology of Ecologists

PAUL B. SEARS

Dr. Sears, who is president of the AAAS, is professor of botany and chairman of the Conservation Program at Yale University. He received his training at Ohio Wesleyan University, the University of Nebraska, and the University of Chicago, and he has taught at Ohio State University, the University of Nebraska, the University of Oklahoma, and Oberlin College. This article is based on a paper presented at a symposium Sociology of Science *that was held by Section L–History and Philosophy of Science on 28 Dec. 1955 during the Atlanta meeting of the AAAS.*

ECOLOGY is the study of interrelationships between life and its environment. Considerable energy has been devoted to the question whether ecology represents a scientific field or a point of view. Some sensible comments on this matter are to be found in a manuscript in the Yale Botany Library, written by W. A. Cooper of the University of Minnesota and sent by him to the late George Nichols for comment. Cooper points out that ecology cuts horizontally across other fields of science and shows how almost any problem that originates in the traditional subdivisions of biology, if carried on to its logical course, emerges into ecology. For the intricate details of structure, function, classification, or genetics derive their final significance as they serve to elucidate the complexities in living nature.

It is also true that the ecologist, in studying the patterns and processes of living organisms in nature, uncovers endless problems to be fed back for solution to the detailed specialties of science. And it should be true that from his vantage point he can form valuable judgments about the strategic importance of various lines of specialized research.

The significance of ecology goes even further, for man himself, however obstreperous and independent he may feel, is a part of the web of life and the living landscape. To see this process of relationship in its broad scientific perspective is the ultimate goal of ecology. To ignore it while we proceed with other scientific activities and applications is like building a beautiful boat in a cellar without measuring the doorways or considering the distance and means of transport to water. What we familiarly call economic or applied biology represents merely the details, however useful these may be in an immediate way. The basic problems of economic biology are those of trends, directions, rates, and broad consequences. These are ecological. They are also important. For what doth it profit man if he gain the whole world only to lose it? We are all familiar with the perennial caricature of the man sawing off the limb he is sitting on.

Much of this is certainly a matter of the common sense that any competent biologist can exercise. And I must admit that I have yet to meet a biologist who shares the optimistic unconcern about natural resources that is so prevalent among a considerable group of technologists and economists.

Yet a closer view of the situation is not very encouraging. If one examines a typical array of introductory textbooks in biology, he will find very few in which the ecological viewpoint is more than a courteous, even perfunctory, chapter. If he examines the catalogs of colleges and universities, he will see that no courses in ecology are offered by many, and that where such courses exist they are often so guarded by a barrier of preliminary requirements that only the more persistent of major students ever get into them. Where honorable exceptions exist, even in the form of an elective course in simple outdoor natural history, we find important recruiting grounds for creative graduate students.

Most serious of all, there are—and I speak from experience—communities of intelligent, public-spirited college graduates who are utterly untrained to analyze some of the most elementary physical aspects of their immediate environment. I should feel sorry enough for them if this meant only the loss of a source of lifelong interest. But in too many cases it has meant their inability to identify and deal with natural processes in time to avoid serious consequences. This applies, for instance, to problems of water supply and flood damage, waste disposal, and allocation of space. Presumably the citizens concerned have all been taught that 2 plus 2 make 4, that two bodies cannot occupy the same

space at the same time, and that water flows downhill. But they obviously have not learned these and other simple principles in the context of the living landscape. Such individuals present the tragic spectacle of living in an age of science and yet learning, as primitive man did through milleniums, only through costly mistakes.

There are many reasons for the situation that I have outlined, and we can here consider only a few. The intellectual lineage of ecology is long and honorable. Its roots lie in the intuitive and empirical knowledge of ancient man who lived, perforce, in intimate relation with the natural world. The invention of agriculture and consequent urbanization did much, of course, to destroy this intimacy. Western philosophy, with its sharp separation of moral from natural knowledge, created a further gap. The prevailing Western notion had been that the world of nature exists only for man and that his ethical pattern includes no reciprocal obligation except to learn enough to get every advantage he can out of nature.

A break in this pattern came with Darwin, who set man back into perspective without diminishing his dignity or responsibility. With Darwin's twofold emphasis—on variation in the organism and on the limiting action of environment—the seeds of two new aspects of science, genetics and ecology, were planted. Both struggled along during the next 40 years. Mendel's law was rediscovered in 1900, and genetics got off to a spectacular career. The two great classics that launched modern ecology preceded this event by a few years—Warming's *Plant Ecology* in 1894 and Schimper's *Physiological Plant Geography* in 1898. Haberlandt's *Physiological Plant Anatomy*, reflecting as it did the plasticity of growth responses to environment, was also an essential contribution.

Although genetics moved rapidly into brilliant achievements, it had its fledgling problems. Emerson, then a worker in horticulture at Nebraska, repeated Mendel's experiments as soon as he heard about them, using beans. His first reports to a seminar met with scornful rebuke, which was later handsomely withdrawn. But until he left for Cornell, he was under constant pressure to work at something "more practical." Elsewhere, even after the work of Morgan should have silenced all critics, there were nearly two decades of skepticism about the role of chromosomes. I saw the last pathetic effort in this direction—a fiery blast by Jeffries that was listened to in stony silence.

Genetics lent itself to precise experimental analysis and quickly gave evidence of its practical application. It also offered a great intellectual challenge, thus attracting superior minds, being in this respect like modern physics, which has created such a vortex for talent. Its remarkable progress and perfection no doubt are due largely to these circumstances.

It is my judgment that, by contrast, the course of ecology has been less orderly and less effective. Certainly it does not admit of the tidy laboratory controls that are so effective in genetics, although experiment in the field is not impossible, and the ecologist comes up with innumerable problems that can be taken into the laboratory. So far as beneficial applications are concerned, ecology has many, besides the fundamental one of providing perspective for all applications of science. Its benefits are generally such, however, that they must be widely diffused through society. No such neat mechanism as physical science possesses in industry and business, or biology in medical practice, exists for it. Rather must its findings permeate through society, or generous segments of it, to become effective—for example, in land-use planning and management. This certainly accounts in part for the haphazard support it receives. An encouraging exception is the recent establishment by the Government of India of a National Institute for Ecological Research.

There remains, by comparison with genetics, the question of intellectual challenge. Certainly, if difficulty and complexity exist in any field, that field is ecology. The challenge is there. Perhaps it has not been made sufficiently visible.

At any rate, the subject has its environment in the general framework of knowledge, while the ecologist exists in an environment both cultural and physical. Let us consider what this means.

The rise of the ecologist almost exactly parallels the decline of the naturalist. An interesting sidelight on this process comes from a story about Darwin, who had invited a number of crack young biologists to his home and asked them, in turn, to tell him about their work in physiology, paleontology, and so on. When they had finished, he thanked them, expressing admiration for their knowledge and regret at the limitations of his own. Then getting up and thumping the table, he said "But damn you, gentlemen, there's not a naturalist in the lot of you!"

The trend was on, toward the fruitful and satisfying precisions of the laboratory. The old fence between natural history and natural philosophy was breaking down, and biologists were crowding into the other pasture. Not even the humanities escaped. In literature there were serious attempts to quantify and to analyze even the plays of Shakespeare by means of graphs and diagrams. Over and above any legitimate need for sound, meticulous work, the student of the living landscape was caught in a

cultural drift and had to assume a kind of protective coloration of professionalism. The ready and obvious way was to discard the old hat of "naturalist," and this was rather promptly done.

But there was cultural inertia, as well as changing style to be reckoned with. When the works of Warming and Schimper made their way across the Atlantic, their visible impact was not in the older centers of learning. Instead, it was at two parvenu midwestern institutions, Nebraska and Chicago.

Some 40 years ago I was shown two very interesting letters, both from venerable universities. One was a complaint that the center of biological influence was shifting from its traditional home to the "barbarian institutions of the middle West." The reference to the two that had treacherously sponsored ecology was unmistakable. The other letter was a request for candidates, which stated that the special interest made no difference, except that the writer did not propose to have an ecologist around. Considering the fact that the first letter was addressed to Charles E. Bessey of Nebraska, an early patron of ecology, and the other to Edgar Transeau of Ohio State, one of the most distinguished of American ecologists, the unconscious humor of the writers was superb. More important, these letters reveal the prevalent mood of the older, more conservative institutions, some of which have not to this day granted house-room to the upstart.

Rather than dwell on this depressing topic, let us look further at Nebraska and Chicago as of the end of the last century. Both were new and plastic. The botany departments at both were under men of evident greatness who had studied under Asa Gray. Gray, himself a taxonomist, was also great and open-minded. His writings are cast in the mold of universal discourse, reading fresh and crisp even today. One of the first and most effective of Darwin's allies, Gray had a keen sense of process, evident in his work on plant geography.

Charles E. Bessey had taken the first college microscopes across the Mississippi to Ames, Iowa, during the 1880's and had carried laboratory instruction thence to Nebraska. By inclination, as well as by his duty as state botanist, he was a naturalist. He was also a library builder. The vigorous young people from town, farm, and ranch who responded to his lively teaching were put in touch with the latest from Europe. And to his dying day, his advice was "Keep your minds in a meristematic condition." So when two of his brilliant young students, Roscoe Pound and Frederick Clements, caught fire from the writings of Warming, Schimper, and Haberlandt, they had his blessing. As a result, botanical literature was enriched by *The Phytogeography of the Nebraska Sand Hills,* the beginning of a long series of ecological contributions to come from Nebraska. Pound, a man of impressive intellect, later went into law. Clements taught for a time at Lincoln, then went to Minnesota and later to the Carnegie Institution of Washington for the remainder of his professional life, dividing his time between the West Coast and the Rocky Mountain area.

Clements, incidentally, was the son of a professional photographer and devised an early instrument for the measurement of actinic light in plant habitats. His photographs of grasslands show great skill in utilizing light and wind direction to give effective results.

Personally, Clements was an austere, almost ascetic individual, although in my few contacts with him I always found him friendly. Beginning with Pound, he always had a close associate or two who formed a useful complement—Weaver, Miss Long, Pool, Hanson, and above all his remarkable wife, Edith Schwartz, who survives him. One of this group has described him as an inspiring source of ideas.

Yet in certain respects, Clements worked and thought in isolation. Not for him was the genial, humorous acceptance of give and take in criticism. Largely this was a matter of temperament. Partly it may have been the result of his distance from the crossroads of learning. And in some measure it may be traced to the fact that, as a pioneer, he had to be self-apprenticed to a considerable degree. Like all of us, he possessed the defects of his virtues.

He was not isolated from the literature. In fact, his masterwork on *Plant Succession* is a gold mine in that respect. But he wrote in a brittle, heavily Latinized style and devised a large number of technical terms that had the effect of creating a considerable prejudice against ecology among biologists at large. Some of these terms have proved themselves and passed into common usage, but many of them remain stumbling blocks to his readers. In this respect he is no worse than certain workers in physical science, complained of in a recent editorial in *Nature,* who use their laboratory slang and notebook abbreviations in journal articles.

Since communication is so integral to science, the infelicity of Clements' writing is of more than idle interest. He was a student during a kind of Golden Age at Nebraska and a member of a group that included not only the Pounds, but Willa Cather, Alvin Johnson, Lieutenant John Pershing, and Westerman the historian. Yet the old classical curriculum was dying a hard death, and I am told that there was a sharp line between the "lits," as they were called, and the scientists, or "Philistines." I have also been told that Clements' heavy use of

Greek and Latin derivatives does not mean that he was much interested in the classics themselves. So I suppose that his absorption in science, plus his concentration on scientific German, cost him that expository skill which would have greatly eased the path of ecology.

I doubt whether Clements ever felt at home in the deciduous forest formation. His milieu was the grasslands and conifer forests of the West. In this majestic empire, which for some decades was a kind of ecological monopoly for Clements and his associates, it is the climatic influences that have highest visibility. This no doubt was the reason why Clements placed less emphasis on physiographic change than did Cowles at Chicago. The net effect was to lead him to broad generalizations, particularly about the "true prairie," that were somewhat difficult for his colleagues farther east to swallow.

At the same time, the minute exactness required in detailed grassland analysis led to a curious paradox. He became more insistent on statistical mapping than did his colleagues in the deciduous forest region. But the net effect of his influence multiplies through the years in the stimulation provided by his ideas.

Henry Chandler Cowles did his undergraduate work at Oberlin College, a liberal arts college that then emphasized the classics but that had encouraged science from the beginning for the interesting reason that the ministers whom it trained should be able to help their pioneer congregations in practical ways. Thus, while science was tacitly assigned second place, it was not a source of cleavage in the educational process.

Cowles went to the new University of Chicago for graduate work in geology with two great masters, Chamberlain and Salisbury. Assigned to a field problem in the West, he returned discouraged because he could not verify the existence of the formation he was supposed to study, and so went over into botany, where Coulter and Barnes were interpreting the new European morphology and physiology, besides giving sound training in taxonomy. Incidentally, later work showed that Cowles' geologic failure was really an evidence of his skill as a field naturalist. He had, quite reasonably, merely failed to find what was not there.

Along with his other gifts, Cowles possessed a nimble mind. It did not take him long to sense the challenge of the dynamic physiography of the Chicago area and its importance as a meeting place for two great plant formations, the deciduous forest and the grassland. His early studies in this area are classics. As an interpreter and inspirer, he excelled, writing and speaking with clarity and force. More than this, he had that priceless gift which is a sure sign of a feeling for proportion—a great sense of humor. This kept him from becoming doctrinaire, from ever relying on method as a substitute for judgment. The geographic position of Chicago and the diversity and power of its faculty made it easy for Cowles to keep in personal, as well as scholarly, touch with the learned world. The fame of the Chicago botany department brought in graduate students from all over the world and subjected them, whatever their specialty, to his leavening influence. Many who took their degrees elsewhere came to spend a season with him in the field, or a term of his lectures in residence. In this way, his influence multiplied incalculably—far beyond what one would judge from the number of his publications.

The systematic launching of animal ecology in the United States owes much to Cowles. Shelford, for example, applied the successional analysis of Cowles in the Chicago Dune region to a study of the beetle communities.

Cowles had a blithe disregard for boundaries and barriers and did his best to break them down. He took an active part in geographers' meetings at a time when W. M. Davis stood like a querulous sentinel to challenge all with his question, "Is this geography?" Ecologists who envy the institutes, societies, and endowments of the geographers should read some of their plaints around the turn of the century. They were not only getting the academic cold shoulder then but are still getting it in some fairly important centers of learning. Neither they nor the ecologists are yet able to do what they might for the average citizen during his period of education. Cowles was certainly far less concerned to chalk off lines between these subjects than to see them united in a common cause.

Another quality that Cowles had was his skill at healing breaches between individuals and groups. Strong as his sense of the ridiculous was, he kept it well under control. Underneath his keen wit lay good humor, a fundamental seriousness, and a desire to have the people around him forget their pettiness and pull together.

In Europe, even before the days of Darwin, ecological foundations were being laid by the plant and animal geographers, von Humboldt, Schouw, and Forbes; by the Scandinavian bog students; by pioneer weather investigators such as Quetelet; by the founders of modern geology such as Geikie and Lyell; and by population students beginning with Malthus. Here and there the ecological implications of the new science of energy, so fundamental to ecological theory, were being caught, although it was 1912 when Ostwald boldly stated his "imperative of energetics." "Waste not free energy: treasure it and make the best use of it."

The true Golden Age of modern creative science was a liberation of intellectual energy nurtured during the 18th century to a dramatic climax in the American and French revolutions. Its flowering in the early 19th century persisted, in somewhat more domesticated form, on through Prussian regimentation, until two wars and its own Frankenstein of technology placed all science in new perspective. The Drakes and Frobishers of science have now been replaced by calculating machines. Even the grand strategy of science has become a matter of calculation, frequently by others than the scientist himself. Practical needs, especially in fisheries and forestry practice, were also having their effect during the 19th century. Studies of this sort were variously called "biology" or "bionomics," even after Haeckel proposed the term *ecology* in 1866. But it remained for Warming and Schimper to give substantial form to a body of knowledge that could really be called by that name. Both were products of the traditionally rigorous European professional training of botanists.

Warming, after a background of experience with both arctic and tropical South American vegetation, turned his attention to the compact, dynamic, yet varied plant communities of his native Scandinavia. He noted the structural and functional characteristics of plants within particular associations, and gave us our classical terms—hydrophyte, mesophyte, and xerophyte. He also enunciated with great clarity the principles of plant succession.

Schimper, like Pasteur, began his scientific work on organic crystals, and achieved a place in botanical history through his studies of starch and chloroplast. Afterward, he applied the remainder of his too-brief life to the interpreting of world communities of vegetation on the basis of functional response to environment: *Physiological Plant Geography.*

So we have, in these two careers, a beautiful and stimulating contrast—Warming moving inward from a wide periphery of interest to a concentrated study of his homeland, Schimper gradually ranging outward from the intensity of his laboratory work to a wide universe of problems. If anyone doubts that science is also, in great measure, essentially an art, his answer is here.

Darwin's part in making clear that life and environment must be studied together has already been noted. Elton quotes Darwin's own observations on the important role of holothurians, constantly feeding on coral reefs, in reducing them to fine mud and thus maintaining an equilibrium, as an example of Darwin's own ability as an ecologist.

Happily Darwinian influence still persists in Britain as a recognizable desire to see things in perspective. Patrick Geddes was a good example. Educated thoroughly but unconventionally, he owed much to the companionship and tolerance of his father, a retired Scots army officer. And, significantly, one of his favorite haunts was a high hill near his boyhood home from which he could view a broad natural and cultural landscape. Later, as a working biologist, he ran into some of the same academic inertia that was met by early ecologists in this country. Some notion of the prevailing atmosphere may be had from his pungent comments on botany. "Is not the popular picture of the botanist," he wrote, "that of a mild yet somewhat mischievous creature, whose chief interest is in picking flowers to pieces, like the sparrow among the crocuses? His remaining occupation is supposed to be that of gentle exercise on holiday afternoons; when, as a kind of sober academic nursemaid, he has to march out with him upon his rounds the unwilling neophytes of medicine, each fitly equipped with a small tin coffin upon his back. His skill the students measure by the frequency with which he stops like a truffle-hunter's pig—say rather like a new, a vegetarian breed of pointer. Hear him loudly ejaculating in the most unmistakably canine Latin as he grubs up the unlucky specimen, as he coffins it with a snap, while the student swiftly scribbles down and forgets, as the one thing needful to know, its technical 'name'. . . .

"The one science which of all others should surely seem most difficult of desiccation and mistreatment is the study of seed and bud and leaf, of flower and fruit, of the garment of earth in all its protean beauty. Yet what science may be made more repellent? And this alike to student and to child, so that the very name of botany stinks in the nostrils of the public and suggests a mere farago of dog-Latin labels upon mouldering hay?"

Eventually Geddes turned to regional planning, and his concept of planning was ecology at its best, with emphasis on history, natural history, and process. His chief exponents in this country have been Lewis Mumford and our own late colleague, C. C. Adams. In Britain his influence is manifest in many ways—for example, in the land-use planning of Stamp and others that proved itself when Britain was sorely beleaguered in the last war.

Another illustrious example is that of Arthur Tansley, whose wisdom and scientific competence have made themselves felt throughout the Empire. Not the least of his gifts is that of lucid exposition. His writings are never muddy or involved, never burdened with jargon. As with Cowles, techniques and methods are regarded by Tansley as proper servants, not masters. It is characteristic of Tansley

that he was nevertheless far more appreciative of the greatness of Clements than were many Americans.

Incidentally, I have been informed that Britain took advantage of the counsel of ecologists at relatively high levels during wartime, with important benefits.

Time does not permit full justice to the numerous and able ecologists on the continent of Europe. My own observation has been that the average continental biologist knows more ecology than his colleagues in this country. At any rate, the small number of permanent posts and the large number of candidates mean long apprenticeships and much manpower available for intensive work. In Europe one finds great variations of habitat in relatively small space. As a result, the continental schools place great emphasis on precise and detailed statistical analysis and on systems of nomenclature to fit. Adding to this the barriers of language and distance, it is small wonder that American workers, still faced with the problem of reconnaissance in a vast continent, are not as familiar as they might be with Swiss, French, and Scandinavian material.

For us, at present, the law of diminishing returns seems to operate strongly so far as primary reliance on intensive methods is concerned. For better or worse, we have an ingrained fear that we may not see the woods for the trees. Whether or not we are justified remains to be seen. I do know of one instance in which an American determined to use the continental approach to a particular community, the cattail or *Typha* community. His aim was to derive a mathematical criterion by which it could be characterized. His report was, after 2 years of conscientious labor, that the only standard he could derive was that of the presence or absence of *Typha*—the cattail—itself. Perhaps the best lesson to be learned from this is that science grows by giving men their hands, and as we used to say of horses in an older generation, their heads.

If these notes have made clear that the ecologist is one of the best examples of his own postulate—the interdependence of environment and organism—I have accomplished my purpose. But let us remember that the genetic qualities of the ecologist, and his cultural, as well as his physical environment, are involved.

Sir Charles Sherrington describes how they kept chimpanzees and other animals in a large well-lighted room. Those that were tame enough were allowed freedom.

"It once happened that George (caretaker) and I, after paying our usual visit to their room, and, on leaving, locking and taking the key with us, asked ourselves what the animals did after we were gone. Tip-toeing back, I put my eye to the keyhole, to look through. The hole seemed obstructed. I could see nothing. Then suddenly I perceived what blocked it was another eye much like my own, looking through at me from the opposite side. A chimpanzee had had the same thought as I, and she—for it was a she—had got there first. Female curiosity!"—E. A. UNDERWOOD, *Science, Medicine, and History* (Oxford University Press, 1953), vol. II, p. 552.

Plane Geometry and Plain Logic

N. A. COURT

Dr. Court, who was born in Warsaw, Poland, during one of the periods when it was under Russian control, received his degree in physical and mathematical sciences at the University of Ghent in 1911. In that year he came to the United States, and from 1916 to 1951, when he became professor emeritus, he was a member of the department of mathematics and astronomy at the University of Oklahoma. Dr. Court is an associate editor of Scripta Mathematica. *This article is based on two lectures, one presented in February 1954 at Oklahoma A. and M. College, and the other presented a few weeks later before the Forum of the Society of Friends of* Scripta Mathematica *at Teachers College, Columbia University.*

THE foundations on which Euclid reared his marvelous *Elements* endured for more than 2000 years. The first effective thunderbolt that struck those foundations originated in a remote Russian town, Kasan, located on the lower reaches of the river Volga, and was hurled at them in 1826 by an obscure professor of mathematics, Nikolai Ivanovich Lobachevski. Lobachevski's object was to prove that the parallel postulate of Euclid was not an obvious truth. In that he was eminently successful. As a by-product, he wrought a change in our conception of the world we live in that has been compared, and rightly so, to the epoch-making achievement of that other Slav, Mikolai Kopernik, better known as Copernicus.

By a queer whim of history, about the time when Lobachevski meditated on his new geometry in Kasan, in another Russian town, Saratov, further down the Volga from Kasan, a young French officer of Napoleon's Grand Army of 1812, J. V. Poncelet, was whiling away his long solitary prison days in another kind of geometrical speculation. His lonely efforts were destined to become the foundation of a new branch of geometry and to form the contents of his famous *Traité des propriétés projectives des figures,* which was published in 1822.

One of the strange ideas contributed by projective geometry is the principle that any of its propositions, in plane geometry, remains valid if we replace in it the points by straight lines and the straight lines by points. As a consequence of this "principle of duality," for each theorem that is proved another theorem is obtained, and the latter is true and does not require a new, direct proof. The number of theorems is thus automatically doubled.

The principle of duality was a great surprise. It was important enough to give rise to an acrimonious dispute over its paternity between two geometrical luminaries, J. D. Gergonne and "the father of projective geometry," Poncelet himself. Nowadays novices to the mysteries of projective geometry are confronted with this principle right at the start, as with a proposition which is practically self-evident. Those of the neophytes who shamefacedly confess that they do not grasp this idea quite clearly are assured by their elders that further progress in their studies will bring more light, and faith will be sure to follow. It does, usually.

The importance of the "windfall" that the principle of duality contributed to geometry is quite obvious. But the philosophic by-product which that principle entailed is even more far-reaching. We have a theorem dealing with certain entities—namely, points and lines. If this theorem remains valid when these entities are replaced by some others (in this case by lines and points, respectively), then our original theorem is not specifically a statement about points and lines. If we press this trend of ideas further, we are in the end confronted with the devasting question: What is it that we are talking about when we make our statements in geometry?

The Formalist Approach to Geometry

Non-Euclidean geometry and the principle of duality called into question the foundations of geometry and of mathematics in general. This was a much-discussed topic during the 19th century, both by philosophers and by philosophically minded mathematicians. Toward the turn of the century, the interest in these matters was greatly stimulated, among professionals and laymen alike, by the philosophical writings and lectures of Henri Poincaré, because of his towering scientific eminence, and perhaps even more because of his literary talent. These essays are excellent reading even today. The

best English edition of most of Poincaré's contributions along these lines was prepared by G. B. Halsted (1).

One outcome of the 19th century discussions was a deeper insight into and a more systematic use of the axiomatic, or formalist approach to mathematics in general, and to geometry in particular. In the case of plane geometry, the method consists in starting out with two kinds of objects named "points" and "lines" about which we profess to know exactly nothing. These objects have for us absolutely no other connotations than those bestowed on them by the propositions we explicitly formulate about them, and by which we are to be governed. These propositions are selected arbitrarily and are declared to be true. When sufficient "axioms" have been accumulated, we are set up in business and are ready to start on the erection of the superstructure, with the help of the powerful lever of pure logic. The most highly regarded work along this line was done by David Hilbert. Thus, in this conception, plane geometry is just one grandiose creation of the human mind, one in which the senses and the sensory world have no part whatever.

Imposing, even inspiring, as the edifice of the formalist may be, the obscurities of its starting point seemed to some to smack of sheer mysticism, and its proud aloofness from the world around us appeared to others to border on the absurd. But the actual heel of Achilles of this purely intellectual doctrine is that it suffers from an inherent intellectual weakness.

The arbitrary choice of the fundamental axioms is subject to an obvious limitation: the axioms have to be logically consistent with each other. Hilbert labored for many years trying to produce a proof that the axioms of his *Grundlagen der Geometrie* satisfied this requirement. But all his persistent zeal and his enormous intellectual resources proved unequal to the task. He could perhaps find some personal consolation in the proposition, proved by K. Goedel in 1931, that the "Grundlagen" could not yield a proof of its own consistency. Georges Bouligand formulates the argument as follows (2): "To find within a body of doctrine G a proof that G is consistent is impossible, for to accept the validity of such a proof is to concede to a part of G a special privilege: an abusive procedure, if the coherence of G as a whole is in doubt." Simple and obvious, David Hilbert to the contrary notwithstanding.

The shortcomings of formalism have brought out the limitations of the axiomatic method but have not impaired its value. Originated more than 2000 years ago in geometry, this method continues to lure other sciences by its undeniable advantages. Among the more recent conquests of, or converts to, the axiomatic method are the biological sciences (3).

Role of the Knower

The geometrical advances that were realized in the first third of the 19th century called into question the validity of the postulates of geometry as well as the nature of the entities it deals with. It was inevitable that sooner or later the instrument that geometry uses to manipulate these materials—namely, logic—should in turn be subject to scrutiny. What are the inviolate laws of logic? How and where have they acquired their infallibility? On what is based their tyrannical power over the mind of man?

And while we are in the questioning mood, would it not be appropriate to cast an inquiring eye on the manipulator of this powerful tool—the geometer himself? Does not the mental and physical make-up of the investigator have a bearing on the results obtained in the investigation? May not the Knower's knowledge depend on the Knower himself? Or, to put it broadly, is not the conception we make for ourselves of the world we live in influenced by the kinds of creatures we are ourselves?

Let us deal with the latter problem first. The questions of the dependence of our knowledge on our own physical and mental constitution are of rather recent origin. In the mental domain they were first considered by Kant. An adequate discussion of the entire problem would require knowledge of our nervous system that at present is not available. But once we raise these questions, the nature of the answer is beyond doubt.

When we look at an object, or at a landscape, and are not quite certain what we see, we turn our heads, or we move closer, or we walk around the object. Our knowledge thus depends on our ability to move—that is, on our physical structure. How utterly different this world of ours would be to us if we were immobile!

We explore our surroundings with our five senses (or is it six?). But what is so fixed and immutable about this number? Could we not have a larger number of them? The question is not quite as preposterous as it might seem at first. We have a sense for light. Why could we not have a sense for electricity? As matters stand now, the only way we can feel that mysterious stuff directly is to be shocked by it, sometimes to death, sometimes into health. If we want to make electricity accessible to our senses, in a less violent form, we resort to the expedient of transforming it into light. But we

could conceivably have nerve ends that would convey to us the sensation of such electromagnetic waves directly. We know that our nerve ends that convey the sensations of high temperatures are different from those that convey sensations of low temperatures. That such an extension of our perceptivity within the domain of electromagnetic waves is not a physiological impossibility is attested by the fact that the visual spectrum of some animals reaches beyond the limits of the visual spectrum of man. For instance, insects, as a class, respond to electromagnetic radiations from both the ultraviolet and the infrared (*4*).

A substantial extension of the range of electromagnetic waves directly perceptible to us through our senses would obviously materially affect our conception of the world around us. Radio astronomy would not have had to lag several thousand years behind optical astronomy (*5*). At any rate, it certainly would have saved us all the time and all the effort that we had to spend, and still do, to study this form of energy by our indirect methods.

If we may find it difficult to talk about additional senses, it is easy to imagine that we might have been deprived of some of those we have. We all know unfortunates who are handicapped that way. Certainly for writers of science fiction such a conjecture is no trick at all—witness the story of H. G. Wells, *The Country of the Blind*. Those who write just science, pure and simple, should not have much trouble either. They know full well that we are blind, at least relatively, compared with other creatures, as was just mentioned.

The well-known limitations of our auditory perceptions offer occasion for analogous remarks.

Axiomatic Method

Federigo Enriques in his *Problemi della Scienza* of 1906 (*6*) points out that the foundations of knowledge are more clearly discernible in knowledge that has already evolved than when it is still at its crude beginnings. This idea was taken up by Ferdinand Gonseth, author of *Les fondements de mathématiques, Les mathématiques et la réalite, Qu'est-ce que la logique,* and so forth. The *Cumulative Index of Books in English* does not list any books by Gonseth. In order to find an answer to the questions bearing on the nature of logic, Gonseth first subjected to a psychological examination the axiomatic method as applied to plane geometry.

A city is described by its plan in a schematic way. This schema usually furnishes information about the location of the streets, the public buildings, the transportation lines, and so forth, but has nothing to say about private residences or the location of the taxicab stations. The plan is thus only a simplified or summary description of the city.

The plan, or schema, is obviously incomplete, and additions may be made to it if necessary. The plan of the city may always be enriched, say, by marks indicating the location of the service stations of any enterprising oil company. Moreover, the things that are indicated on the plan are represented by conventional marks or symbols.

Thus the schema is a summary, symbolic and unfinished. The city that the schema represents may be said to be the exterior meaning or the *exterior significance* of the schema.

However, we may consider this schema by itself and for itself, without reference to the thing that it is supposed to represent. As such, the schema has its own reality and may be an object of study for its own sake. We may, for instance, examine the network of lines indicating the one-way streets or the pattern formed by the points marking the locations of the post offices and relate it to the similar pattern formed by the telegraph offices. We may even solve some geometrical problems that those figures might suggest. Of course, by these intrinsic considerations regarding the schema, we are diverting our attention from the plan's original purpose. On the other hand, such studies may well be undertaken in order to serve that very purpose with greater efficiency. The profound analogy between this example and geometry is so transparent and so striking that it can hardly be overlooked.

In order to accept the edge of a ruler as a realization of the abstract concept of a straight line, we must, in the first place, reconcile ourselves to the approximate character of this realization. But this is not enough. We must also be willing to forget that the correspondence between the concept and its realization holds only macroscopically and that it vanishes completely when the edge of the ruler is put under a microscope. In other words, the realization of the concept is only summary. What we said of the straight line can obviously be repeated about any other concept used in geometry. In the light of our example with the plan of a city, we say that rational geometry is a schema of ideas whose exterior significance is to be sought in a certain natural structure of the physical world. We are thus quite far from the much quoted quip of Bertrand Russell: "In mathematics we don't know what we are talking about, or whether what we say is true."

Pursuing our analogy between rational geometry and the plan of a city, we may say that to set up our geometrical schema means to conceive, in a summary and schematic fashion, a set of simplified notions and a number of relationships among them.

To reason intrinsically on this schema means to render explicit the consequences implied in those relationships. In other words, to develop the reality of the schema is to set up a system of statements having the value of axioms, and the business of the geometer is to reason intrinsically on this schema.

The process of constructing an abstract schema in correspondence with a given exterior significance may be called "abstraction by axiomatization."

Let us observe that the schema is the *abstract* of its exterior significance and that the latter is the *concrete* of the schema. Abstract and concrete are thus relative to one another. Their mutual correspondence, as well as their opposition, constitutes a part of their meaning.

Meaning of Intuition

There is, however, an important difference between the schematization of a city and that of geometry. We have no hesitation how to perform the first task. But it is not quite as clear how to go about picking for geometry "a system of statements having the value of axioms." When we considered the axiomatization of the straight line, we assumed that the notion of a straight line is familiar to us. We know the thing "by intuition." Euclid's axioms have been accepted through the ages, as given "by intuition." Let us try to examine what this notion "*by intuition*" means.

Our accumulated knowledge is perpetuated and transmitted from generation to generation largely through books. More than 3000 years ago, a wise man voiced a complaint that "of making many books there is no end" (Ecclesiastes: 12, 12). No part for this blame may be attributed to children, for children do not write books. But children, even infants, acquire a considerable amount of knowledge about the surroundings they live in and make a vast number of adaptations to it.

The adult, however, by the time he is ready to write a book, is prone to forget about the things he learned in his early life without the benefit of books. Relying on his personal recollections, any adult would, for instance, staunchly maintain that he had always been able to walk, if his observation made on his very youngest contemporaries did not shatter this quaint illusion.

Suppose you take two flat sticks, say, two rulers, of equal length, hold them in your two hands so that they cover each other, and then slide them part way one on the other. It would not occur to you to resort to measurements in order to settle the question: Which of the two uncovered parts is longer? You know for sure that those two parts are equal, and you have always known that to be true. Now, have you? No, there was a time when you did *not* know it. That was the time when, after having counted up five of your wooden toy blocks, you entertained high hopes that there might turn out to be six of them, if you arranged those same blocks in a different order (*7*).

Knowledge of this sort is "intuitive" geometry. We accumulate a considerable body of this kind of information at an early age. By the time we are confronted with our first textbook on geometry, we are pleasantly suprised to find how much of the stuff we know already. And by the time we feel called on to write on or about geometry ourselves, we pass those things on for "common sense" and as "self-evident, intuitive truths" (Euclid), or for "knowledge a priori" (Kant), while they are actually no more and no less than empirical information that had been acquired very early in the hard and exacting school of living and acting in a certain environment.

Foundations of Logic

One of the basic entities that preoccupies the logician is the concept of "object." One commonly conceives of an object as a quantity of matter packed into a portion of space and having well-defined boundaries. This is a very useful idea, well adapted to our human needs, for the purposes of action. But when they are subjected to the closer scrutiny of the physicist, these qualities of common objects, as well as others that we associate with such objects, retain a validity that is only approximate and provisional. We thus arrive at the conclusion that the conception of a "given object" is the outcome of an effort of abstraction bearing on the shape, motion, and other preceptive qualities of common objects. In other words, the idea of an "object" derived from our everyday experience is only summarily correct, just as is the idea of a straight line that is suggested by a stretched string.

Following up this analogy, we may attempt to axiomatize the concept of "any object" in order to facilitate its study from the point of view of logic.

This process of systematic axiomatization will require a further schematization of the idea of "object" itself, as well as of the conjoint idea of the presence of the object somewhere, or of its complete absence.

In the first place, the idea of "object" will have to be divested of the notion of the object being present at a definite spot or place. The idea of object will just remind us that the object is, or is not. This idea of presence or absence, when pushed

farther, results in the idea of pure existence or nonexistence.

Furthermore, the strictly practical notion of the permanence of the object with regard to its own properties leads to the abstract notion of its *pure identity* with itself. This notion, combined with the notion of pure existence or nonexistence, results in the abstract of existential identity.

To render this idea of existential identity more concrete, let us consider two different marks, say A and B. Suppose it so happens that neither could be written down without the other likewise being written, and that neither could be crossed out or erased without the same happening to the other. Moreover, the only matter of concern is to ascertain their presence or their absence. Under such circumstances, no confusion could arise if either one of the two marks A, B, is taken for the other. This practical equivalence of A and B is a good realization of their purely *existential equivalence*.

Going a step further, the same thing may be restated if, instead of two different marks, twice the same mark were drawn—that is, two distinguishable realizations of the same mark, say A, but again provided that only the question of presence or absence is involved. The two realizations may then be considered as identical. This practical identity realizes the abstract idea of *existential identity*.

Let us take the idea *any object* as our undefined term. We are now ready to formulate the axioms governing that term. It should be recalled that the axioms aim to point out, or reproduce, in connection with the abstraction considered, the salient properties of the concrete representations of that abstraction, or better, the properties that are inherent in the intuitive image we have of those concrete representations.

The realization of the abstract notion of existential identity by the practical equivalence of two copies of the same symbol quite naturally suggests the following.

Axiom 1. Any object is identical with itself.

To this axiom we shall add two more, based on our practical experience and on our everyday knowledge of the rules of presence and absence of material objects:

Axiom 2. Any object is, or is not.

Axiom 3. An object cannot be and not be at the same time.

The three axioms represent, respectively, the principle of identity, the principle of the excluded middle, and the principle of contradiction.

The upshot of our efforts at abstraction by axiomatization is thus the idea of "any object" governed by the laws of being, or not being, and the law of existential identity with itself, but which is otherwise undetermined. This eminently abstract idea of an object might be called the "abstract object" or the "logical object."

The concrete object realizes the logical object in the same way as the stretched string realizes the geometrical straight line. The idea of pure existence of the logical object is realized by a natural or concrete object in the same fashion and to the same degree as the ideal rectitude of a straight line is realized by the crude rectitude of the string. But no concrete object realizes the abstract object any closer than it can realize the geometrical idea of a point.

These observations simply emphasize the fact that in the present case, as in any other abstraction by axiomatization, the relationship between the concrete and the abstract is adequate only in a schematic way. The degree to which it is necessary to simplify the common, intuitive notion in order to achieve this correspondence is clearly shown by our effort to establish the principle of identity.

Symbolic Representation, or Miniature Realization

Let A be the symbol of an object whose existence or nonexistence has not been specified, and let $\underline{A}$ and $\overline{A}$ be the symbols for A's existence and nonexistence, respectively. The three marks $\underline{A}$, A, $\overline{A}$ are three concrete objects. With reference to them, our three fundamental axioms take on the following forms:

Axiom 1. The letter A has everywhere the same significance.

Axiom 2. Each determination of A is expressed by its being either underlined or overlined.

Axiom 3. The latter two cases are mutually exclusive.

It is essential to observe that in those three statements all the words used have their ordinary meanings. There is no mention of purely existential identity or of pure existence. The reason for it is that in formulating these statements we have entrusted ourselves to our intuitive and practically certain knowldge concerning three signs drawn on paper.

To put it in other words, these three symbols and the formal rules that they have to obey are a miniature realization of the abstract schema that we have devised. This abstract schema is the link that establishes a correspondence between the three symbols A, $\underline{A}$, $\overline{A}$, the concrete number 2, so to speak, and the concrete number 1—namely, the common objects with which we started in the first place. However, we are prone to forget about the existence of this connecting link and see only the two concretes facing each other; the original concrete upon which we were reluctant to operate

and the new concrete, much reduced and more readily handled.

The undetermined object symbolized by the "abstract form" A may be filled, or it may be empty. The concrete realization, or model of this form, may be perceived in any object that may, at will, be brought into the field of attention, or may be far from it. The form $\underline{A}$, on the other hand, symbolizes an existing object.

Now consider two objects that have no apparent tie and that may be treated independently of one another. True, a sufficiently close examination of any two objects is likely to result in the discovery of some kind of a relationship between them. But we shall gloss this over. If our two objects are, for instance, two books, their independence, for our purpose, may manifest itself in the fact that the two books may be in, or out of, the library independently of one another. This schematic form of independence is an abstract concept that may be adequately represented by two "forms of objects" admitting, without preference or distinction, the four eventualities shown in Table 1.

Table 1. Four eventualities.

No.	In words	In symbols
1	A is and B is	$\underline{A}$ and $\underline{B}$
2	A is, but B is not	$\underline{A}$ and $\overline{B}$
3	B is, but A is not	$\overline{A}$ and $\underline{B}$
4	Neither A is nor B is	$\overline{A}$ and $\overline{B}$

The enumeration of these eventualities may perhaps incline the reader to think that any two objects are always independent. But that is not the case. The two independent objects that are existentially equivalent, considered in a previous paragraph, are just objects for which the eventualities 2) and 3) do not exist. We could also conceive of two objects for which the eventualities 1) and 4) are excluded, by definition. This is the case of mutual exclusion.

The case when only eventualities 1 and 4 are valid may be rendered concrete by two persons who always enter and leave a certain room at the same time; and the case when only eventualities 2 and 3 are valid is made concrete if one of those two persons leaves the room whenever the other enters, and vice versa.

These two examples show, by the way, that the relationships of equivalence and exclusion that we imagined between two forms are schematizing some close relationships that may exist between material objects.

Rational Theory of Objective Existence

The concept of the set of the eventualities 1, 2, 3, and 4 considered as freely admissible may be referred to as the "abstract form relative to two abstract objects." If one, or two, of these eventualities is left out, a less extended form, or a "subform," is obtained. Thus a pure and simple eventuality is the least extended form. We may also say that a subform "enters" into a more extended form, or that the latter "contains" the former, if all the eventualities of the former are also eventualities of the latter. Every subform enters into the complete form. Two subforms overlap, or are mutually exclusive, according to whether they do or do not possess a common eventuality.

Using this terminology, we may state the following new axiom: Two determined objects which enter into the form of equivalence cannot enter into the form of mutual exclusion. The realization (involving two persons) that we have considered makes it clear that this statement (axiom) formulates an empirical law of the world of material objects, a very primitive law, and therefore one of practically unfailing validity.

Thus, starting with the most common and the most elementary properties of material objects, and applying the axiomatic method as exemplified in plane geometry, we arrived at the concepts and the rules of pure existence. These ideas are basic in Gonseth's *Rational Theory of Objective Existence*; Gonseth's theory axiomatizes one of the first chapters of physics, if not the very first—namely, the one dealing with the existence, the presence, and the absence of objects of any kind. In other words, the physics of any object and the rational theory of pure existence are two phases of the same undertaking, the former being the external significance of the latter.

For the subject at hand, the importance of the rational theory of existence is that all the laws of elementary logic may be expressed in the form of rules of existence, as was quite apparent when we sketched those ideas, and may be substantiated by further analysis. But we shall not pursue this argument. The detailed treatment may be found in Gonseth's own writings.

Logic

The conclusions to be drawn from the preceding discussion are as illuminating as they are far-reaching. The rules of pure existence being the schematized properties of common objects, the same holds for the equivalent laws of logic. Hence, the common sense of logic and its intuitive rules are seen to be the outcome of a schematization that is based

on our experience in the world of common objects.

Furthermore, since the abstract laws that logic formulates have their origin and their realization in the domain of concrete objects, those laws take on the significance of very primitive natural laws and are therefore practically infallible. That is what accounts for their usefulness, on the one hand, and for their irresistible power over us, on the other hand.

Our distinguished contemporary Maurice Frechet, professor of mathematics at the Sorbonne, put the question of the origin of logic in a nutshell: "The rules of logic start with an approximation of the real, and that reality is rediscoverable even in the remotest conclusions drawn from those laws. Is it just by lucky accident, independently of all experience, that those laws impose themselves upon our mind? Or is not our acceptance of those laws from our predecessors due to the fact, taught us by our daily experience, that if we apply those laws correctly, we are never mistaken? We are thus not far from concluding that logic itself is a product of our experience, that logic is the result of an inductive synthesis. It is therefore quite legitimate, and even very useful, to submit logic to a process of axiomatization. This axiomatization, like that of any other science, must be considered as being only an essentially revisable schematization of the practical rules of reasoning. But we are certain that we shall always be able to utilize our logic, without change, in the major part of our scientific research." In brief, the empirical origin of logic is obvious a priori, despite the firm conviction of all those thinkers through the ages for whom the laws of logic were inherent laws of the mind. But then, the principle of duality turns out to be obvious, and so does Goedel's theorem. It would seem that nothing is more effectively hidden in the farthest recesses of obscurity than is the obvious.

Since our laws of logic are derived from our practical experience, our reasoning can be valid only as long as we apply it to our environment as it is here and now, so to speak. This may cause trouble in some unsuspected and unsuspecting quarters. Take the great phalanx of enthusiastic space travelers, young and otherwise, that has sprung up in the wake of the rockets of recent invention. These travelers are beset by a great many worries and difficulties. But the fun-seeking excursionists to neighboring planets, as well as the intrepid conquistadores of new galaxies, may discover, to their amazement and chagrin, that the logic which they had found so reliable as long as they stayed home, goes "haywire" when they get abroad.

But remaining peacefully at home offers no guaranty of the permanent validity of our logic. Should our environment change, we would have to change our logic accordingly. This may sound fantastic, but it is not outside the realm of the possible. In fact, in a way, we are already in the midst of such a change right now, and have been for about half a century. Quantum theory, the new atomic theory, and the theory of relativity have confronted us with phenomena that operate on a scale either too vast or too minute compared with those on which our senses received their education and training. No wonder that we run into "inconsistencies" and "contradictions." The physicists have had to reexamine many of our notions that were well established according to our "common sense." Recently, P. W. Bridgman, devoted a lucid article to these difficulties (*8*). The logicians, for their part, try to meet the newly arisen problems by introducing multivalued logic.

Our discussion of the origin of the laws of logic has brought into the open the limitations of those laws and should thus contribute to a better understanding of that wonderful instrument our human race is so proud of—the power of reasoning. We have convinced ourselves once more that our source of knowledge lies in closer contact with our environment. Is it not this idea that the Greek mythology wanted to express by imagining the demigod Anteus whose power endured as long as he maintained contact with the earth?

The same idea may be found in the play *Chantecler* of the French poet Edmond Rostand. This is the way the mighty Chantecler explains to his friend the pheasant hen where he derives his power to call out the sun from below the horizon: "I never start to sing until my eight claws, after clearing a space of weeds and stones, have found the soft, dark turf underneath. Then placed in direct contact with the good earth, I sing." We, too, have to be "in contact with the earth" if we want the light of knowledge to shine on us.

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LETTERS

The Meaning of Protoplasm

As a traditionalist in language, I rise to the defense of the honorable word *protoplasm,* which was attacked by Garrett Hardin on metalinguistic grounds [*Sci. Monthly* **82**, 112 (1956)]. The pitfalls in language are real, and our own language does have defects of detail (in science teaching we are most plagued by the second meaning of "why?" which invites teleological thought). But we grow up with our language, and at the college level we should be ready to use it effectively, just as any imperfect tool may be skillfully used.

As children we hear such words as *good* in a wide range of contexts, perhaps even starting with approval of regular elimination; the abstraction with all its varied applications is developed slowly. So a college freshman may meet *protoplasm* for the first time as an abstraction, naked but for the loin cloth of a definition. The examples cited by Hardin are not all good definitions, but each is a legitimate starting point. From there on, it is the task of student, teacher, and text to develop the concept. To be sure, the word may be postponed. But it is not good merely to describe this molecule, that enzyme, and these processes out of context, as though *in vitro.* They occur in relationship, in a matrix of organization. If one starts with *protoplasm,* there must be analysis, but in the end there should be resynthesis. The same difficulties apply to every integrative concept: *organism, evolution, life.* But who would throw out the baby with the turbid bathwater of linguistic difficulties? Psychologists have dropped *mind* from many textbooks, but this may be partly justified by reaction to a real history of unnecessary mind-brain dualism. *Protoplasm* does not have such a history, and it need not be forced onto one branch of a dichotomy.

Hardin's talk of the "thinghood" of protoplasm ("it must imply a structure in a bipolarized picture of livingness") is about a straw man of outgrown concepts. Why can the word not grow with the concepts? Certainly *protoplasm* is not incompatible with the concept of an open system if that is the way protoplasm behaves. All real "things" involve substance, process, and pattern; and the same applies to all real processes and patterns. Our choice of term may legitimately shift with the intended emphasis.

An unfortunate lapse of logic introduces the measured decline of *protoplasm* in the index of *Biological Abstracts*: "If *protoplasm* is really useless, or detrimental, then we should be able to show that the word is being used increasingly less often by those engaged in thinking and research." The data might equally indicate that those engaged in the details of particulate research are finding less opportunity to express their thinking at the integrative level to which *protoplasm* is appropriate.

Parenthetically, one should take exception to the degree of emphasis supplied by the graph. My 6-year-old daughter was smitten with sympathy for Gillespie's creature. I explained that this was a symbol for a word on its deathbed (see how the line goes down) and a word that I would hate to lose; hence I am writing this letter. After a quick extrapolation (see where it would be this year) she urged me to hurry, and to write several letters if that would raise it from the dead. I had to point out that even if the points were real, the line is imaginary and ill-fitted to the points. And words do not die as straight-line functions, so 1955 was not crucial. She is only partly reassured, being still impressed by print.

Admittedly, it is difficult to keep the teaching of elementary biology up to date in its viewpoint. But it is at this very level that we need the complete cycle of analysis and resynthesis, and this cannot be done by avoiding integrative concepts. If research workers do not help teach elementary biology, and if they bury their heads in the sands of particulate experiments to the point of ignoring *protoplasm,* they will do a disservice to biology.

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Validity of Test Items That Involve Finding a Pattern in Data: a Rejoinder

A letter by Gerald C. Helmstadter has been published [*Sci. Monthly* **81**, 209 (1955)] in reply to my article, "Validity of test items that involve finding a pattern in data" [*Sci. Monthly* **80**, 50 (1955)]. Since the letter is based on a profound misinterpretation of my article, much of what it contains is irrelevant. I should like to discuss some of the criticisms offered.

Helmstadter arbitrarily selects one of the four

definitions of validity presented in my article—correlation with an external criterion—and claims that ". . . the crucial judgment regarding the validity of the item should be based on its predictive validity—that is, in terms of whether or not it will differentiate those who are later most successful from those who later are less successful." In an earlier paragraph, he said that "success in science might be judged by such different things as grades in science courses, highest degree an individual has received, salary in scientific work, judgment of colleagues, number of papers published, number of outstanding discoveries made, or any combination of such variables."

This interpretation of the validity of the items is absurd if one is interested not in predicting how successful an individual will be but rather in appraising the individual's present ability to find patterns in data. As a teacher, I am interested in the possibility of using the items to evaluate my instruction. If I could measure an individual's status before and after instruction, I could answer the question: How much has my teaching changed the individual's status in ability to find patterns in data? Perhaps an individual who has a lot of such ability can do some scientific work, but later success or lack of it is useless as an index to the effectiveness of my instruction on this point. It is useless because it shows nothing about a change in status produced by teaching. Also, it is contaminated with the effects of other factors, including willingness and ability to get along with people, willingness to work, and so on. In my article, I did not discuss the use of number series to predict success in science. My question throughout was: How well do these items measure what we have assumed they measure, the ability to find patterns in data?

Helmstadter then interprets my remarks about the creative act as an attack on the possibility of forecasting the degree of success likely to be achieved by certain individuals. The best interpretation that I can make of my own remarks is: The accomplishment of a specified act of creation by a specified person in a specified situation is uncertain. This, I think, is supported by common experience: for example, the general cause of cancer has not been discovered yet even though many competent people have been trying to find it. I am unable to follow the line of reasoning by which Helmstadter arrived at his interpretation. Perhaps his view is something like this: The accomplishment of a specified act of creation by a specified person in a specified situation is certain, but our predictions of it are only probable. However, it seems pointless to inquire further into his reasoning. I did not say what Helmstadter has inferred from my remarks and I do not wish to say it. In principle, making predictions of success seems to be no different from making other predictions based on observed uniformities in experience and based on the faith that such uniformities will be repeated.

The portion of Helmstadter's reply that is devoted to the two views I have discussed seems to me to be irrelevant. Helmstadter does suggest, however, two rules for getting "the correct solution" to a number series item, even though ". . . infinities of schemes are possible which would account for any series of numbers." If these rules were acceptable, they would avoid two of my serious criticisms and would be highly significant contributions. I find that neither of these rules has any value, however. The first rule says: "(i) accept the explanation that can be formulated on part of the data and tested on the rest of the data in preference to one that requires extrapolation to data not at hand. . . ." This rule offers no help at all in distinguishing any of my schemes from the others, for the first five numbers in each scheme are the same. This is the point of the several illustrations. Consequently each of the schemes "can be formulated on part of the data and tested on the rest of the data," or none can be.

What Helmstadter means by "None of Lampkin's schemes can be formulated without postulating additional data . . ." is not clear to me. Perhaps he means that one needs a firm foundation of facts before one makes an inductive inference. If this is his idea, it is different from the view, which I accept, that guessing is justifiable and unavoidable. Even if voluminous data are in hand, there will still be many alternative schemes by which the data can be summarized. The final test of our theories seems to be the prediction of facts that can be observed. When Helmstadter describes his two rules as rules ". . . that most scientists who were not able to gather further data at the moment would follow," he implicitly refuses my criticism that number series test items do not permit experimental testing. Helmstadter seems to wish the test subjects not to guess; then they will not need to test.

Let us consider Helmstadter's second rule: "(ii) accept the solution that is most simple." Helmstadter continues, ". . . there would be little disagreement that the rule 'add two' is less complicated than any of the alternate solutions proposed by Lampkin." Now it is surely a fallacy to justify an idea by saying that no one will disagree. More-

over, how does Helmstadter tell when one idea is simple and another complex? He offers no set of criteria, and I suspect that the task of providing one is very difficult. With regard to the present illustration, the simplicity of the rule "add two" seems controversial. If the rule is intended to be equivalent to scheme A, $x_n = 2n - 2$, the statement of it is surely elliptical. In similarly elliptical form, schemes G and H can be stated as "move down two"—in a table of trigonometric functions. Furthermore, the rule assumes that the specimen item is written in the decimal number system; it might well be written in the nonary number system in which following the rule "add two" would produce 11 and 13 as the next two terms. Which number system a person uses depends in part on cultural factors.

My article points out that 83 percent of the items cited are solved directly or indirectly by use of successive differences. Helmstadter comments that ". . . in some instances it may even be desirable to have a training component in a test." If it is desirable to measure understanding of, and competence in using, the method of successive differences, would it not be desirable rather to test directly for it?

Helmstadter continues, "When it is desirable to exclude special background and training, there are methods by which a test constructor can estimate the extent to which they are important in answering any item and thus use this information in selecting items that will be included in the final form of the test." I do not know of any investigations showing what procedures the subjects actually do use in answering the items. A summary of the types of relationships that I found in the 409 test items cited was deleted from the original paper in shortening it to meet editorial requirements. I suspect that if all the items that yield to successive differences were eliminated, the 17 percent remaining would be too difficult for use with the present test population that extends down to grade 4. I do not know of any statistical procedures that can eliminate cultural factors such as those I have mentioned in the discussion of simplicity. If such procedures are known to others, perhaps the procedures can be applied in making number series items, and also in making intelligence tests, that do not depend on reading and other experiences of children in a particular culture. It may be possible to resolve the controversy over changes in the I.Q. of children.

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Present Growth and Advance of Boulder Glacier

Recently, in "What's happening to our glaciers!" I expressed concern over the rapid shrinking of glaciers in the Cascade region [*Sci. Monthly* **81**, 57 (1955)]. Since about 1950, however, the majority of the glaciers in this region have been growing. A. E. Harrison and Kermit Bengston report that many of the north Cascade glaciers are obviously larger now than they were in 1950, or still covered with snow (personal communication). Harrison estimates that the Coleman Glacier, on the north side of Mount Baker, has advanced 250 feet during the year that ended 23 September 1955.

Having now completed some studies of Boulder Glacier on Mount Baker, I find that this glacier is also advancing. Mount Baker, a glacier-covered Pleistocene volcanic peak, is located in northwestern Washington about 35 miles east of the city of Bellingham.

The total area covered by glaciers on Mount Baker in 1908 was 24.7 square miles. Because the surface area of the ice in 1947 was between 19 and 20 square miles, a reduction of about 5 square miles in area covered by the glaciers is indicated for the intervening 40 years. During the last 200 years, Boulder Glacier has receded 9650 feet; the rate of retreat increased after the early 1900's (Table 1).

Aerial photographs taken in 1931, 1940, and 1947 show Boulder Glacier in a state of recession. From the 1931 photograph, the position of the terminus was determined with considerable accuracy, and the amount of recession undergone by the glacier terminus between 1931 and 1940 was measured. By 1947, melting had left a smooth, thin, dirty, and partly moraine-covered inactive tongue of ice extending about 2000 feet beyond the much thicker clean ice higher on the mountain. Since 1947, however, Boulder Glacier has been growing in its upper region. The thin, stagnant ice tongue melted rapidly between 1947 and 1953, but during the same interval the clean or "living" ice thickened.

Table 1. Retreat of Boulder Glacier.

Period (years)	Recession (feet)
1750–1850	1350
1850–1880	1250
1880–1931	3900
1931–1940	1000
1940–1954	2150

Fig. 1. Boulder Glacier on 5 **August 1953.** The view **shows the advancing** wave of **ice bowed outward,** heavily **crevassed, and** overriding **dirty, inactive** terminal ice.

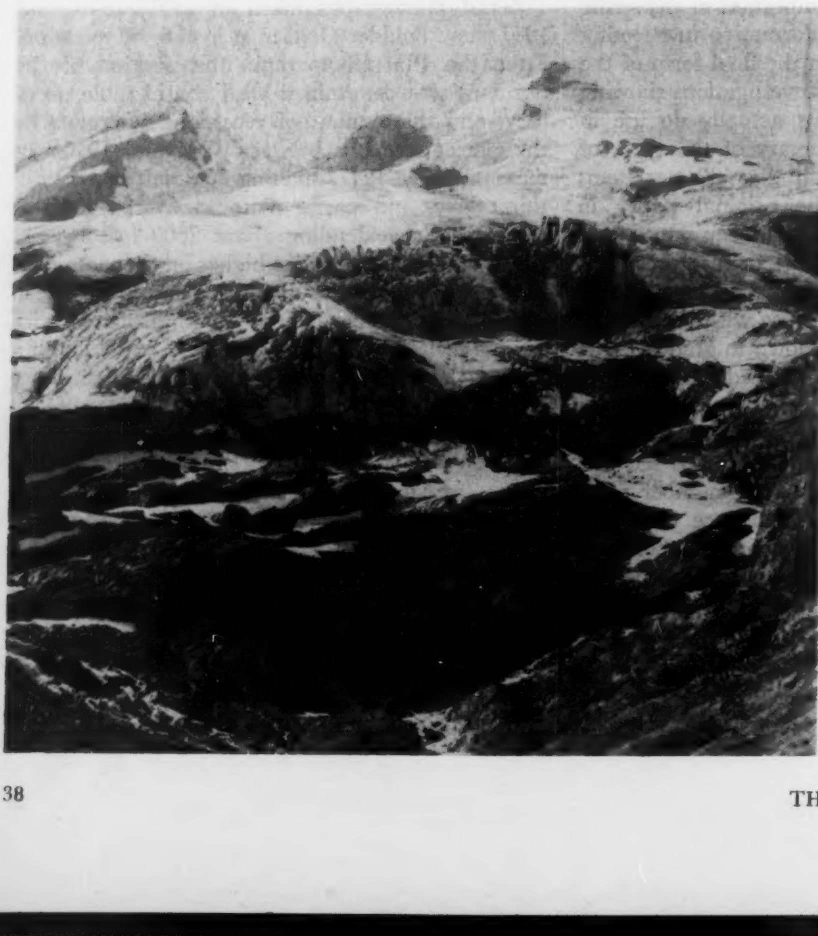

Fig. 2. Boulder Glacier on 21 **August 1955.** Note that the **smooth, dirty,** inactive **terminal ice extending** beyond **the central ice cliff** in Fig. 1 **has been pushed** forward and **heaped up by the** rapidly **advancing,** active ice front. **When this photograph** is **compared with Fig.** 1, the **increase in thickness,** width, **and length of the** glacier is **very obvious. In Fig.** 1, the **active ice margin** lies behind **the rock bluff** at the left **center of view,** whereas in **Fig. 2 the ice** has almost **completely overridden** the **bluff.**

An advancing wave of ice, built up since 1944 during years characterized by heavy winter snows and cool summers, has moved down and through the previously thin retreating terminal ice and has rejuvenated the entire glacier front. By 1950 the advancing wave of ice had moved to the edge of a large rock bluff that had been exposed by the downward wasting of the ice. Three years later, the advancing wave had buried the rock and had overridden most of the remaining thin, inactive terminal ice (Fig. 1), which, however, continued to retreat until it was met in 1954 by the advancing wave of ice. There is now a truly advancing front at Boulder Glacier.

The picture of Boulder Glacier on 6 September 1954 was one of much glacier activity, with the remaining thin, stagnant ice being pushed forward and heaped-up by the rapidly advancing active ice front. That the flow of the ice is very strong is attested by the definite thrust planes formed by the flowing ice behind, which is overriding the inert basal ice. Where they are exposed in ice cliffs at the snout, these thrust or shear planes are well developed.

During the past year the glacier has increased visibly in length, width, and thickness (Fig. 2). From 6 September 1954 to 21 August 1955, Boulder Glacier advanced a distance of 170 feet.

Check measurements of the glacier will be made annually from a large and permanent rock outcrop located on the valley floor about 3000 feet below the 1954 terminus. This outcrop is at the position of the 1931 terminus of the glacier.

Boulder Glacier should continue to advance for several more years because the wave of advancing ice, which reached the terminal margin in 1954, is now pushing rapidly down the barren glacial trough. There are visible indications that sufficient thickness and amount of new ice are present to push the terminus at least several hundred feet beyond the present ice margin.

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Erratum: In the article "Acid-base terminology," by Thomas P. Nash, Jr., in the May 1956 issue, the statement at the end of the next to last paragraph in the first column on page 256 should read "(iii) alkalemia (pH > 7.45)."

BOOK REVIEWS

Stratigraphic Geology. Maurice Gignoux. Translated from the fourth French edition, 1950, by Gwendolyn G. Woodford. Freeman, San Francisco, 1955. xii + 698 pp. Illus. $9.50.

To a nonstratigrapher, this is a formidable tome weighted with unfamiliar geographic and stratigraphic names, but, even if only by the sheer multitude of terms, it becomes an impressive and potentially influential achievement. Gignoux has attempted, in one sense, to do for Western Europe in terms of sedimentation and stratigraphy what Eardley tried to do for the United States in terms of structural geology. The result is a series of stratigraphic syntheses or "sedimentary landscapes" collated into a "harmonious succession of coherent geographies."

Originally conceived as a textbook, this fourth French edition has also been assembled as a documented tool for the professional geologist. It should serve well as a source reference for Euorpean geology and as an illustration of one geologist's interpretation of a plethora of stratigraphic detail in a voluminous and not always accessible literature. As Gignoux points out, physics is physics whether in London or San Francisco, whereas geology and geologic syntheses tend to be colored by the time, the country, and the personality. Gignoux's book expresses and applies his thoughts on the organization and interrelationships of sediments and sedimentation extended to explanations of sedimentary series or paleogeographic units.

The table of contents lists an introduction and 11 chapters. The customary introductory prefaces, in this case at least, shed some light on the objectives and guiding concepts. The introduction, from one viewpoint, is the most important section, because it is here that Gignoux presents his philosophy of stratigraphy and its relationship to geology and outlines the framework for his subsequent examples. The 11 chapters are each a discussion of one geologic period wherein the principles of the introduction are applied to several regions. Within the introduction, which is relatively short, the general principles are set down in the first three sections: (i) "The materials of stratigraphy (the sediments)"; (ii) "Stratigraphic syntheses (the concept of the stage)"; and (iii) "Definitions or methods."

Two major types of sediments or facies are recognized, continental and marine. Continental

sediments are deposited on the rigid continental mass in basins of subsidence or where the agent of transport lost its power (glacial and desert). Marine sediments are distinguished by three great groups: detrital, organic, and pelagic. These sediments develop in two major types of regions, the continental or stable areas and the geosynclinal regions where the plastic substratum reacts to tectonic stresses as wavelike folds. Sedimentary series are grouped as continental, epicontinental, and geosynclinal. A stage, as Gignoux uses it, is a stratigraphic synthesis involving lithologic and paleontologic definitions of formations from which sedimentary facies and provinces are recognized. The facies and provinces are then grouped into sedimentary series, each series corresponding to a paleogeographic unit or landscape and thereby stratigraphic geology becomes a harmonious succession of such geographies.

In the chapters that follow the introduction are many examples of stratigraphic syntheses, but the reviewer will leave it to each stratigrapher to analyze critically Gignoux's syntheses. The analyses of periods starts with the Pre-Cambrian in Chapter 1. Chapter 2, "The Cambrian," is followed by Chapter 3, "The Silurian"; Gignoux considers the Ordovician as one great stage of the Silurian. Then in order are the Devonian, Permo-Carboniferous, Triassic, Jurassic, Cretaceous, Nummulitic or Paleogene (Eocene and Oligocene), Neogene (Miocene and Pliocene) and in conclusion the Quaternary. The chapter outlines are much the same, differing only in detail. A typical chapter is illustrated by the following brief outline resumé of the one on "The Cretaceous."

The opening paragraphs set the scene for the division of the Cretaceous into lower and upper stages. The Cretaceous fauna is covered in a general manner with regard to the classes important to the Cretaceous and some of the more important groups in each class. The third section discusses the Lower Cretaceous of southeastern France, the stages of the infra-Cretaceous transgression between southeastern France and England, and the Northern Basin (Northern Europe). Next is a discussion of the Upper Cretaceous of the Paris Basin, Northern Europe, and the French Mediterranean. The Cretaceous of the western Alps makes up a separate section concerned with the internal zone of the French Alps and the Swiss Alps followed by sections on the eastern Alps, Carpathians, and Apennines, the Iberian Peninsula, North Africa, and North America. In all of these sections and in the general conclusions, Gignoux tries to fit the stratigraphic (paleontologic, petrographic and structural) data into a framework of continents bordered by a continental platform followed by a foredeep (geosynclinal zone), a cordillera, and finally a deep.

At the close of each chapter is a list of the literature citations and explanatory or short discussion comments referred to in the text. For the 66 pages in the Cretaceous chapter there are 199 such reference notes. The illustrations and tables throughout the book are pertinent and readable without difficulty. Possibly, even more illustrations would be helpful for those who are not familiar with the details of European geology. The book is remarkably free of typographic errors.

The translator is to be highly commended for a task well done in taking a foreign language book and making it available to American geologists in familiar language but without apparently changing the original meaning of the author. The book will probably serve more as a source of reference than as a textbook. As a reference it will be excellent for European geology and for examples of the application of stratigraphic principles. It should be particularly valuable for those interested in historical geology and the interrelationships between sedimentation and tectonics, regardless of whether or not they are in complete agreement with Gignoux's interpretations.

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Races and People. William C. Boyd and Isaac Asimov. Abelard-Schuman, New York, 1955. 189 pp. Illus. $2.75.

The aim of this book is apparently to say all that can, at present, be said in an elementary but scientifically exact way about human races. The sentences are short, the words are small, and the sequence of ideas is carefully controlled. One detects a conscious effort to keep the language sterile of all emotions; witness, for example, the restraint of this passage (p. 15): "Sadly enough, in most of the country, Negroes, although no longer slaves, are still treated with less consideration than are white men. In some regions the prejudice against them is, unfortunately, quite strong." One suspects that the authors were motivated to carry through the hard work of writing the book by feelings considerably stronger than those that show through the language just quoted. At times, perhaps, accuracy itself suffers from the habit of qualification; for example, it is stated (p. 109) that "Queen Victoria of England may have been heterozygous" for the hemophilia gene. Considering that she had

one hemophilic son and two daughters who presented her with hemophilic grandsons, the caution of the phrase "may have been" seems excessive.

It is not possible now, of course, to give a scientific evaluation of race without presenting the technical fundamentals of genetics. This is the most difficult part of such a popularization. On the whole, the authors have done an admirable job in presenting this material in layman's language and with great brevity. It might be questioned, however, whether it is wise to use eye color in human beings as the prime example of a simple one-gene Mendelian trait, developing it in detail in both text and diagrams, only to end up by an admission that human eye color really is not this simple at all, and had we better not talk about Mendel's peas now? It is only two chapters later that the authors introduce the far more satisfactory traits, human blood antigens; but they lead the reader away from the proper topic by discussing technical details of blood transfusion that are really irrelevant to their purpose. Nevertheless, their treatment of blood factors is lucid and competent, as one would expect of such able biochemists. It is unfortunate that the publishers have not seen fit to identify the authors on the title page or in a laudatory introduction, for the layman quite properly wants to know on what authority he is asked to accept the many facts which cannot possibly be completely supported by evidence in a popular presentation.

Once the heredity of blood factors is made clear, the question of races is attacked again in the admirably clear and concise ninth chapter. Seven races are distinguished: Australian, Amerindian, Asian, African, European, Early European, (of which the Basques are a relict) and Indo-Dravidian. The point is explicitly and repeatedly made that racial differences are differences between populations, not between individuals.

In closing, Boyd and Asimov tackle the great "what of it" question, the relevance of genetic facts to the challenge of eugenics. They conclude that the best course for us to pursue at the present time is one of simple nonintervention. What we need first is (p. 173) ". . . knowledge and more knowledge. Genetics, especially human genetics, is still a terribly young science, and much remains to be learned." In the meantime, they expect and hope that man's increasing mobility will thoroughly mix together all the gene reservoirs of the world into one great pool, thus producing many new gene combinations. In a passage notable for its optimism (p. 174), the authors suggest that the mixing process may lead to the solution of the eugenic problem: "There would be more subnormal people, perhaps, but there would be also more people of unusual talent. Since the important advances of mankind are probably due to the few individuals of unusual ability produced each generation, producing more of them would be very good. Some of these individuals might help advance genetics to the point where we needed to wait for chance no longer." *Deo volente.*

GARRETT HARDIN
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The Windward Road. Adventures of a naturalist on remote Caribbean shores. Archie Carr. Knopf, New York, 1956. xvi + 258 + viii pp. Plates. $4.50.

The subtitle of this book is the "Adventures of a naturalist on remote Caribbean Shores," which aptly describes its contents. Whatever else the author is, as a professional herpetologist and educator, he is clearly and fundamentally a naturalist in all of the old, full meaning of the word. His adventures are drawn from many visits to various parts of the Caribbean over a good many years, all ostensibly in search for the breeding grounds of sea turtles. The search is part of a serious investigation of the breeding habits and migrations of the green turtle in particular, which is in great need of international conservation laws if only the right laws can be devised.

So Archie Carr has tramped the beaches, always on the windward side of the land where the trade wind blows and the turtles come ashore to lay their eggs in the sand above the tidal surf, usually where men or dogs promptly dig them up. From the Spanish Main to the Grand Cayman and the beaches of Trinidad and Tobago, he has searched assiduously during season after season, always looking for turtles but also aware of all other creatures, human or otherwise, that have come his way. He was especially on the lookout for frogs, for which he gained a liking in his youth.

This is a charming book, both in style and in content, so that the reader not only shares the adventures, which are enjoyably human rather than disturbingly exciting, but comes to know both the man and the people he meets. More than this, the reader tends to get almost emotionally involved in the efforts and intentions of a sloth moving toward another sloth in the trees of the city park of Puerto Limón, or of a shrimp disconcertingly crossing a bridge to dive into a torrent above the windward shore of Trinidad, or a hawksbill turtle hunting for a place to lay its eggs on the wrong kind of beach.

Inevitably other books come to mind that keep

this one company, as Gilbert Klingel's evocative account of a naturalist's year on the lonely island of Inagua, in which one gets the same feel of sand and water and the steady pressure of the trade wind. Carr's narrative of the tropical beaches and rivers of Panama and Honduras, of the Mosquito Indians, of Turtle Bogue, and of sloops that carry the turtles to Florida past the Isle of Pines, recalls the youthful William Dampier of some three centuries earlier, making records in his journal while he was cutting logwood with otherwise out-of-work pirates in the forests of Yucatan. Much has happened since those seemingly far-off days when buccaneers and others stocked live green turtles on board their ships as the mainstay of their diet. The turtles are pitifully few compared with their former abundance, and the turtle fleet is in danger of passing away as completely as the old sea captains themselves. This is the theme of Carr's book and also his deep concern, for year by year the wilderness itself is dwindling.

N. J. BERRILL
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Proceedings of the UNESCO Symposium on Typhoons, 9–12 November 1954, Tokyo. Japanese National Commission for UNESCO, Tokyo, 1955. xiv + 257 pp. Illus.

These proceedings are a compilation of the papers read before the UNESCO Symposium on Typhoons that was held in Tokyo, Japan, from 9 to 12 November 1954. The meeting was well attended, with over 45 regional delegates and observers representing most of the weather services affected by typhoons in the Pacific. Both research- and review-type papers are presented. All papers are in English.

It is particularly gratifying to see that the discussions following the individual papers are fully reported. These are too often deleted in similar reports in this country. On the debit side, the proofreading, particularly of the Japanese contributions, is quite poor and at several points definitely slows the reading.

The proceedings give a good view of the energetic and fruitful research being conducted by the various Japanese agencies on the typhoon problem. More than half of the papers are by Japanese. In particular, the paper by Sasaki and Miyakoda on the prediction of typhoon tracks on the basis of numerical weather-forecasting methods appears to merit further study.

A short historical note: C. E. Depperman, S.J., is back in typhoon research, the field to which he contributed so greatly during the period before World War II.

These proceedings definitely deserve a place in the library of all researchers on typhoons and tropical storms.

C. A. PALMER, JR.
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La Prospection de l'Uranium. Manuel pratique à l'usage de tous. Preface by Marcel Roubault. Commissariat à l'Energie Atomique. Masson, Paris, 1955. 59 pp. F. 450.

After a preface by M. Roubault in which he calls attention to the risks of careless prospecting, especially for uranium, the brochure follows the usual books directed to finding uranium. It deals with methods, description of chief uranium minerals, and the use and diagrams of Geiger-Müller counters with the interpretation of what the counter records into suitable maps. The scintillator is not mentioned, but fluorescence and chemical tests are discussed. The brochure closes with a chapter giving a short description of the various rock beds in which uranium minerals may occur.

The ideas expressed differ little from similar publications put out in other places. The two color plates are unique, as far as I know, showing eight different minerals from pitchblende to parsonite. Of course, it is directed at the picture as developed in France.

E. WILLARD BERRY
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You and the Atom. Gerald Wendt. Whiteside and Morrow, New York, 1956. 96 pp. $1.95.

In December 1953, the president of the United States proposed "Atoms for Peace" in a United Nations address. One year later the United Nations Assembly approved without dissent and asked its executive head to call an international conference to further the proposal. In August 1955, such a conference, held in Geneva, Switzerland, added its impetus to the concern that atomic energy be geared to peaceful uses.

UNESCO is an agency of the United Nations. It has a responsibility for furthering world-wide education; hence, it should participate in a program of "nuclear energy for constructive services." Its sponsorship of the preparation and publication

of this small book is a part of its share in that program. UNESCO's director-general, Luther H. Evans, wrote the book's preface.

The plan of presentation includes, after an introduction, chapters on "Energy" (fuels, foods, and other chemical sources); "Nuclear fuels" (performance and products); "Sources" (historic and current); "Reactors" (structure and operation); "Power" (control and utilization); "Radioactivity" (menace or blessing?); "Tracers" (the by-product bonus); and "Prospects" (the author peers into the future).

Nine line drawings and diagrams offer graphic aid to the reader. A unique combination glossary-index provides a limited reference service. A commentary-type bibliography also helps. Gerald Wendt's well-known vivid and interest-holding exposition bids engagingly for continued reader attention. All in all, this book is an able demonstration that it is possible to have *multum in parvo*. The busy person with limited time for reading will find this a *best brief* presentation of a much publicized subject.

B. CLIFFORD HENDRICKS
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Elements of Quantitative Analysis. Theory and practice. Hobart H. Willard, N. Howell Furman, and Clark E. Bricker. Van Nostrand, Princeton, N.J. ed. 4, 1956. 576 pp. Illus. $5.85.

In this new, fourth edition of a well-known textbook, a junior author (C. E. Bricker) has been added. Although casual examination indicates considerable resemblance to previous editions, closer inspection reveals extensive revision and reorganization.

Part I (90 pages), "Introductory material," includes an introduction, general operations for gravimetry and titrimetry, the balance and weighing, evaluation of data, and fundamental laws and theories.

Part II (209 pages), "Titrimetric methods," is the most extensively treated section. The theory and illustrative procedure of the 11 chapters cover most of the conventional kinds of titrimetric reactions, such as precipitation, complex formation, neutralization, and oxidation-reduction, in this order. Incidentally, the Nomenclature Committee of the Division of Analytical Chemistry recommended that the word *iodometry* not be used, since thiosulfate is the titrant in the processes to which the word refers.

Part III (62 pages), "Gravimetric determinations," comprises two chapters, the first devoted to the general problem of preparing and handling precipitates, and the second devoted to procedures for ten commonly determined constituents. All of these examples are limited to separation by precipitation.

Part IV (156 pages), "Separations," shows the greatest change in this edition. I have long believed that separation, as such, has no essential connection with any particular kind of measurement. Here, then, one finds precipitation, electrodeposition, extraction, adsorption, and volatilization, treated in this order. I believe that Chapter 20, "Gravimetric separations," is misnamed, since gravimetric is a kind of measurement; and I would classify the familiar carbon dioxide procedure (p. 393) as a volatilization separation. Fortunately, what one calls methods does not affect their applicability.

The authors have succumbed to the instrumentalists enough to include two brief chapters, "Colorimetry and spectrophotometry" and "Electrometric methods." However, these chapters do not seem to belong in part IV, "Separations."

The statement of the Bouguer-Beer equation (p. 486) recommended by the joint committee of the American Society for Testing Materials and the Society for Applied Spectroscopy is

$$\log_{10} I_0/I = A = abc$$

in which A is absorbance, a is absorptivity, b is thickness, and c is concentration. Then the value of the constant, a, depends on the values of b and c, and the units used to express them. a_M (or ϵ) is molar absorptivity.

This book has enjoyed wide usage, and the new edition will no doubt appeal to many teachers.

M. G. MELLON
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Atom Harvest. Leonard Bertin. Secker & Warburg, London, 1955. 253 pp. 20s.

Atom Harvest is a popular history of the development of the British atomic energy effort. The story begins with the discovery of nuclear fission and traces in careful detail the progress of the United Kingdom atomic energy effort to the present time. The book is written in such a lively fashion that, despite many necessary references to specific individuals, the pace never drags and the reader never loses interest. One of the features of Leonard Bertin's style is his ability to describe succinctly the important qualities of each of the principal characters in the British program.

When the British accomplishments of the last 10 years are viewed as a whole, the reader realizes and marvels at the tremendous pace with which British atomic energy successes have been achieved. It is nothing short of a miracle that in one decade it has been possible for a country that was ravaged by war to carry out a well-integrated nuclear program of planning and achievement in the fields of both weapons and peaceful utilization.

To an American reading the book, it is impossible to overlook the attitude with which the author regards the American project. It is clear that Bertin believes that the United States intentionally froze the British out of all the important parts of the joint project in order to guarantee America a future monopoly in the peaceful applications of atomic energy. As represented by Bertin, there is an open sore in Anglo-American relations brought about by the United States' failure to fulfill its agreements in the wartime nuclear partnership. I must confess that I have never detected in my British colleagues the degree of aggravation at the United States presented by Bertin. It *is* clear, however, that an element of competition has developed between the two countries as a result of the circumstances that surrounded the atomic energy program at the close of World War II.

In the closing pages of the book, Bertin strikes at the heart of the English point of view. He points out quite sharply that atomic energy has been chosen by the United Kingdom as a device of international, as well as domestic, policies through which the British hope to improve their standard of living at home and to solidify the position of the pound sterling abroad. The reader is left with the realization that only a small extrapolation of performance during the past decade is required to accomplish this lofty aim. British atomic energy is just beginning to surge forward. The dedication and perseverance of the central figures in the British enterprise make it seem quite reasonable that the real atom harvest will begin in the near future.

ROBERT A. CHARPIE
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Men, Rockets and Space Rats. Lloyd Mallan. Messner, New York, 1955. 335 pp. Plates. $5.95.

Lloyd Mallan's book is based on visits to various Defense Department establishments, laboratories, test centers, and proving grounds and on interviews with numerous scientists, engineers, and technicians. The book is supremely interesting when it deals with the various tests in the field of space medicine and when it describes the people involved in this work. The subject matter is quite broad and meanders a great deal.

The author discusses experiments in high-speed sleds, in Skyhook balloons, and in rockets and makes a brief excursion into the artificial satellite field. There is a brief glossary attached that is rather useful for people who do not know the very special language used in the field.

On the whole, Lloyd Mallan has done very nicely in filling in the human side of high-altitude research.

S. F. SINGER
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The Gardener's Bug Book. Cynthia Westcott. American Garden Guild and Doubleday, New York, ed. 2, 1956. xxii + 579 pp. Illus. $7.50.

This is a second edition of the author's successful handbook of control of plant pests for home gardeners, which appeared under the same title 10 years ago; it has been "completely rewritten and reset." The insects, mites, nematodes, and other small members of the animal kingdom that attack man's gardens, esthetic and dietetic, have not generally changed their identities or their habits, but the once simple list of stomach and contact poisons used against them has multiplied. As Cynthia Westcott, professional "plant doctor," points out in her preface, the number of new synthetic chemicals (some of them dangerous to man) now on the market warranted a revision; she keeps the 6204 trade names of these 32,000 registered pesticides to a minimum, but her dictionary of garden chemicals requires some 22 pages.

A few pests have been added; altogether about 1100 of the more troublesome species (not all of them "bugs") most likely to be encountered in home gardens and on ornamentals are discussed—with control emphasized. Although these garden pests are grouped alphabetically under their common names—for example, aphids, cutworms, weevils—the index assists the learned by including scientific names as well (these have been brought up to date, too). For beginners with gardens, perhaps meeting a caterpillar on a cabbage leaf for the first time, the section on host plants and their pests may serve as a key. The 36 color plates of 102 pests and the 94 line drawings are good. In short, those with gardens and the will to spray or dust to protect them should find this a convenient and practical reference book on control measures for their garden pests.—R. L. T.

Famous Problems and Other Monographs. F. Klein, W. F. Sheppard, P. A. MacMahon, and L. J. Mordell. Chelsea, New York, 1955. xix + 321 pp. $3.25.

This volume includes the reprints of four mathematical monographs. Its title is taken from the first monograph *Famous Problems of Elementary Geometry* by the great Felix Klein, published in German in the year 1895 and then translated into many other languages. The English translation is by W. W. Beman and D. E. Smith, with supplementary notes (mostly of a historical character) by R. C. Archibald. In a masterly manner, Klein discussed questions of elementary constructions by means of straightedge and compasses for the classical problems of the duplication of the cube, the trisection of an angle, and the quadrature of the circle. He also discussed the possible elementary constructions of regular polygons and finally gave the (more difficult) proofs for the transcendental character of the numbers e (Hermite) and π (Lindemann). This last result then implies the impossibility of squaring the circle by elementary means.

The three other monographs are *From Determinant to Tensor* by W. F. Sheppard (1923) in which tensors are discussed in general as well as in their more limited sense, as applied to the theory of relativity; *An Introduction to Combinatory Analysis* by P. A. MacMahon (1920); and *Three Lectures on Fermat's Last Theorem* by L. J. Mordell (1920). This last monograph treats, in a lucid manner, Fermat's (in general still unproved) "last theorem"—that is, the conjecture that the equation $x^n + y^n = z^n$, for any integer $n > 2$, cannot be solved by (nonvanishing) integer values of x, y, z. Proofs for the elementary cases $n = 3, 4, 5, 7$ are discussed, and then the deep and original research of Kummer and his introduction of ideal numbers is very clearly and readably presented. It may be added that at present (going beyond the results quoted by Mordell) Fermat's conjecture is proved for every integer $n > 2$ that is smaller than 2521.

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Books Reviewed in SCIENCE

4 May

Temperatur und Leben, H. Precht, J. Christophersen, H. Hensel (Springer). Reviewed by L. von Bertalanffy.
Modern Physics, J. C. Slater (McGraw-Hill). Reviewed by J. S. Toll.
The Alkaloids, Chemistry and Physiology, vol. V, R. H. F. Manske, Ed. (Academic). Reviewed by W. F. von Oettingen.
Poliomyelitis, International Poliomyelitis Congress (Lippincott).

11 May

Electro-Sleep, V. A. Giliarovskii, N. M. Liventsev, Y. E. Segal, Z. A. Kirillova (State Publishing House of Medical Literature). Reviewed by S. A. Corson.
Clays and Clay Minerals, A. Swineford and N. Plummer, Eds. (National Academy of Sciences–National Research Council). Reviewed by V. T. Allen.
Biochemical Preparations, vol. 4, W. W. Westerfeld, Ed. (Wiley; Chapman & Hall). Reviewed by R. C. Corley.
The Marine and Fresh-Water Plankton, C. C. Davis (Michigan State University Press). Reviewed by R. W. Pennak.
Semimicro Qualitative Analysis, F. J. Welcher and R. B. Hahn (Van Nostrand). Reviewed by R. A. Whiteker.
Physics of Fibres, H. J. Woods (Institute of Physics). Reviewed by H. F. Schiefer.

18 May

Progress in the Chemistry of Organic Natural Products, vol. XII, L. Zechmeister, Ed. (Springer). Reviewed by B. Witkop.
Faune de France, 59, A. Hoffmann (Lechevalier). Reviewed by D. G. Kissinger.
Chemical Methods of Blood Analysis, S. D. Balakhovskii and I. S. Balakhovskii (State Publishing House of Medical Literature). Reviewed by S. A. Corson.
Fibrous Proteins and Their Biological Significance, Symposia of the Society for Experimental Biology, No. IX (Academic). Reviewed by J. H. Edsall.
Dielectric Behavior and Structure, C. P. Smyth (McGraw-Hill). Reviewed by A. A. Maryott.
Arctic Research, D. Rowley, Ed. (Arctic Institute of North America).

25 May

Comprehensive Inorganic Chemistry, vol. 4, M. C. Sneed and R. C. Brasted, Eds. (Van Nostrand). Reviewed by B. B. Cunningham.
Primates: Comparative Anatomy and Taxonomy, vol. 2, W. C. O. Hill (Interscience; University Press). Reviewed by G. E. Erikson.
Lehrbuch und Atlas der Anatomie des Menschen, Rauber-Kopsch, vols. 1 and 2 (Thieme). Reviewed by W. L. Straus, Jr.
Progress in Organic Chemistry, vol. 3, J. W. Cook, Ed. (Academic; Butterworths). Reviewed by F. Ramirez.
Official Methods of Analysis of the Association of Official Agricultural Chemists, W. Horowitz, Ed. (Association of Official Agricultural Chemists). Reviewed by A. M. McElroy and J. I. Hoffman.
Preventive Medicine in World War II, vol. III, E. C. Hoff, Ed. (Office of the Surgeon General, Department of the Army).

New Books

The Religion of Negro Protestants. Changing religious attitudes and practice. Ruby Funchess Johnston. Philosophical Library, New York, 1956. 224 pp. $3.

Art in Coinage. The aesthetics of money from Greece to the present day. C. H. V. Sutherland. Philosophical Library, New York, 1956. 223 pp. $7.50.

Police Drugs. Jean Rolin. Translated by Laurence J. Bendit. Appendix on *Narcoanalysis* by Edward V. Saher. Philosophical Library, New York, 1956. 194 pp. $4.75.

An Outline of Social Psychology. Muzafer Sherif and Carolyn W. Sherif. Harper, New York, rev. ed., 1956. 792 pp. $6.

The Prevention of Cruelty to Children. Leslie George Housden. Philosophical Library, New York, 1956. 406 pp. $7.50.

Psychoanalysis and Psychotherapy. Developments in theory, technique, and training. Franz Alexander. Norton, New York, 1956. 299 pp. $4.75.

The New Psychology for Leadership. Based on researches in group dynamics and human relations. Donald A. Laird and Eleanor C. Laird. McGraw-Hill, New York, 1956. 226 pp. $4.

Noradrenaline. Chemistry, physiology, pharmacology, and clinical aspects. U. S. von Euler. Thomas, Springfield, Ill., 1956. 382 pp. $11.50.

World Symposium on Applied Solar Energy, Proceedings. Held at Phoenix, Ariz. 1–5 Nov., 1955. Sponsored by Association for Applied Solar Energy, Stanford Research Institute, and University of Arizona. Association for Applied Solar Energy, Phoenix, 1956. 304 pp. $5.

Wonder World of Microbes. Madeleine P. Grant. Whittlesey House, McGraw-Hill, New York, 1956. 160 pp. $2.75.

Trigonometrical Series. Antoni Zygmund. Chelsea, New York, ed. 2, 1952. 329 pp. Cloth, $4.95; paper, $1.50.

Tables of Weber Parabolic Cylinder Functions. Computed by Scientific Computing Service Limited. Mathematical introduction by J. C. P. Miller. Her Majesty's Stationery Office, London, 1955 (order from British Information Service, New York). 233 pp. $11.68.

Surface Area. Lamberto Cesari. Princeton University Press, Princeton, N.J., 1956. 595 pp. $8.50.

The World of Plant Life. Clarence J. Hylander. Macmillan, New York, ed. 2, 1956. 653 pp. $8.95.

Irrationalzahlen. Oskar Perron. Chelsea, New York, ed. 2, 1951. 199 pp. Cloth, $3.25; paper, $1.50.

Rockets and Guided Missiles. John Humphries. Macmillan, New York, 1956. 229 pp. $6.

New Concepts of Healing. Medical, psychological, and religious. A. Graham Ikin. Association Press, New York (rev. American edition; printed in Great Britain by Hodder & Stoughton, 1955), 1956. 262 pp. $3.50.

Man, His Life, His Education, His Happiness. A. Da. Silva Mello. Translated by M. B. Fiers. Philosophical Library, New York, 1956. 729 pp. $6.

Modern Marine Engineering. D. W. Rudorff. Philosophical Library, New York, 1956. 154 pp. $4.75.

Machine Design. Joseph Edward Shigley. McGraw-Hill, New York, 1956. 523 pp. $7.75.

Modern Naval Architecture. W. Muckle. Philosophical Library, New York, 1956. 154 pp. $4.75.

Modern Chemical Processes. A series of articles describing chemical manufacturing plants. vol. 4. Editors of *Industrial and Engineering Chemistry* and the technical staffs of the cooperating organizations. Reinhold, New York; Chapman & Hall, London, 1956. 202 pp. $5.

Famous Problems of Elementary Geometry. F. Klein. Translated by Wooster Woodruff Beman and David Eugene Smith. Notes by Raymond Clare Archibald. Dover, New York, rev. ed. 2, 1956. 92 pp. Cloth, $1.50; paper, $1.

Faculty Requirements and Standards in Collegiate Schools of Business. Proceedings of a Conference on Professional Education for Business held 27–29 Oct., 1955 at Arden House, Harriman Campus of Columbia University. American Association of Collegiate Schools of Business, New York, 1955. 216 pp.

Geometrical Optics. L. C. Martin. Philosophical Library, New York, 1956. 215 pp. $7.50.

Experimental Thermochemistry. Measurement of heats of reaction. Prepared under the International Union of Pure and Applied Chemistry by the Subcommission of Experimental Thermochemistry. Frederick D. Rossini, Ed. Interscience, New York, 1956. 326 pp. $7.80.

Exceptional Children. Florence L. Goodenough assisted by Lois M. Rynkiewicz. Appleton-Century-Crofts, New York, 1956. 428 pp. $4.50.

Genetics. The modern science of heredity. Edward O. Dodson. Saunders, Philadelphia, 1956. 329 pp.

Germanium Diodes. S. D. Boon. Philips Technical Library, Eindhoven, Netherlands, 1956. 85 pp.

New Concepts in Flowering-Plant Taxonomy. J. Heslop-Harrison. Harvard University Press, Cambridge, 1956. 135 pp. $1.25.

The Descent of Pierre Saint-Martin. Norbert Casteret. Translated by John Warrington. Philosophical Library, New York, 1956. 160 pp. $4.75.

Deliver Us from Evil. The Story of Viet Nam's Flight to Freedom. Thomas A. Dooley. Farrar, Straus and Cudahy, New York, 1956. $3.50.

Color Atlas of Oral Pathology. Histology and embryology, developmental disturbances, diseases of the teeth and supporting structures, diseases of the oral mucosa and jaws, neoplasms. U.S. Naval Dental School, National Naval Medical Center. Lippincott, Philadelphia, 1956. 188 pp. $12.

The Conquest of Mt. McKinley. Belmore Browne. Houghton Mifflin, Boston, new ed., 1956. 381 pp. $6.

Electric Circuit Theory and the Operational Calculus. John R. Carson. Chelsea New York, ed. 2, 1953. 197 pp. Cloth, $3.95; paper, $1.88.

The Thirteen Books of Euclid's Elements. Translated from the text of Heiberg with introduction and commentary by Thomas L. Heath. 3 vols. Dover, New York, rev. ed. 2, 1956. 432 pp.; 436 pp.; 546 pp. Paper, $5.85 (set of 3 vols.).

Automata Studies. C. E. Shannon and J. McCarthy. Princeton University Press, Princeton, N.J., 1956. 285 pp. Paper, $4.

The Unknown—Is It Nearer? Eric J. Dingwall and John Langdon-Davies. New American Library, New York 22, 1956. 160 pp. Paper, $0.35.

The Legacy of Sigmund Freud. Jacob A. Arlow. International Universities Press, New York, 1956. 96 pp. $2.

Grundlagen der Allgemeinen Vitalchemie in Einzeldarstellungen. vol. I, *Die physikalische Grundlage des lebenden Systems: Atom und Molekül.* Karl Kaindl. 1955. 201 pp. S. 192. vol. II, *Die physikalisch-chemische Grundlage des lebenden Systems: Ordnungszutände und Reaktionsgeschehen.* Karl Kaindl and Stefan Holzel. 1956. 138 pp. S. 186. Urban & Schwarzenberg, Vienna-Innsbruck, Austria.

Intermediate Analysis. An introduction to the theory of functions of one real variable. John M. H. Olmsted. Appleton-Century-Crofts, New York, 1956. 305 pp. $6.

Great Men. Psychoanalytic studies. Edward Hitschmann. Sydney G. Margolin, Ed. International Universities Press, New York, 1956. 278 pp. $4.

The Human Heredity Handbook. Amram Scheinfeld. Lippincott, Philadelphia, 1956. 276 pp. Illus. $3.95.

Handbuch der Laplace-Transformation. vol. II, *Anwendungen der Laplace-Transformation.* Gustav Doetsch. Birkhauser, Basel-Stuttgart, 1955. 436 pp. DM. 52.

Introduction to the Theory of Groups of Finite Order. Robert D. Charmichael. Dover, New York, (unaltered republication of ed. 1, 1937), 1956. 447 pp. Cloth, $3.95; paper, $2.

Bacterial Anatomy. Sixth symposium of the Society for General Microbiology held at the Royal Institution, London, April 1956. E. T. C. Spooner and B. A. D. Stocker, Eds. Cambridge University Press, New York, 1956. 360 pp. $6.

Birthplace of the Winds. Ted Bank II. Crowell, New York, 1956. 274 pp. $4.50.

Chemical Applications of Spectroscopy. vol. IX of *Technique of Organic Chemistry.* W. West, Ed. Interscience, New York, 1956. 787 pp. $15.

Mental Health and Infant Development. Proceedings of the International Seminar held by the World Federation for Mental Health at Chichester, England. vol. 1, *Papers,* 308 pp.; vol. 2, *Case Histories,* 289 pp. Kenneth Soddy, Ed. Basic Books, New York, 1956. $4.50 per volume.

The Direction of Human Development. Biological and social bases. M. F. Ashley Montagu. Harper, New York, 1955. 404 pp. $5.

The Biochemistry and Physiology of Bone. Geoffrey H. Bourne, Ed. Academic Press, New York, 1956. 875 pp.

Agricultural Ecology. Girolama Azzi. Constable, London, 1956 (order from Essential Books, Fair Lawn, N.J.). 424 pp. $7.20.

Plane Trigonometry. E. Richard Heineman. McGraw-Hill, New York, ed. 2, 1956. 239 pp. $3.75.

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ASSOCIATION AFFAIRS

Preliminary Announcement of the Seventh New York Meeting

Since its founding more than a century ago, the American Association for the Advancement of Science has held 122 national meetings. One of the fundamental purposes for which the association was founded, in September 1848, still endures: ". . . by periodical and migratory meetings to promote intercourse between those who are cultivating science. . . ." In recent years the association has also increasingly recognized its responsibility to inform the general public on scientific developments and its obligation to assist all organizations concerned in the encouragement of qualified young people to prepare for, and enter, careers in science. All of these objectives will influence the programs this year.

For its 123rd meeting—the annual meeting of 1956, 26–31 Dec.—the association will return to New York, for the seventh time, and after an interval of 7 years. As in 1949, this large assemblage of research scientists, teachers, research directors, university presidents, engineers, and other science-minded professional men and women will occupy the five hotels closely grouped around the Pennsylvania Railroad Station. The Statler and New Yorker are among the largest in the nation; there are available, with the Sheraton-McAlpin, Governor Clinton, and Martinique, 6700 rooms for transient guests and an exceptional number and variety of session rooms, all of them committed to the use of the AAAS and the participating societies. Since these five hotels are such close neighbors—interconnected by tunnels in three instances—a particularly unified, convenient, and time-saving meeting is assured.

Center of the group, the Hotel Statler will be AAAS Headquarters and site of all general events and the large-scale exhibits. The mezzanine of the Statler not only has a large ballroom (capacity 1800) and other session rooms, but it can also accommodate the AAAS Main Registration-Information Center, AAAS Office, AAAS Press Room, AAAS Science Theatre, Zoologists' Lounge, and the Annual Exposition of Science and Industry, sponsored by the association for the 33rd time. These exhibits of the latest in the materials and tools that scientists use—and of the technical accomplishments of large industries—will occupy the Ivy Suite, Foyer, and Georgian Room just opposite the ballroom. With so many session rooms in one hotel—most of them on the mezzanine level—and all the hotels so near one another, the exhibits can be visited repeatedly, during any spare moment, and with a maximum of convenience. Exhibitors have already recognized this fact and, at this time, more than 6 months in advance of the meeting, most of the available boothspace has been rented.

Among the general events scheduled for the ballroom and adjacent areas are the AAAS Presidential Address and Reception on the evening of 28 Dec. At this event, Paul B. Sears will preside, and George W. Beadle will give his retiring address. The distinguished evening lectures of RESA, Sigma Xi, and the United Chapters of Phi Beta Kappa, as well as the AAAS Smoker on the evening of 29 Dec., are all scheduled for the ballroom or adjacent Keystone Room. The two afternoons of 27 and 28 Dec. have been set aside for the two parts of the AAAS General Symposium, "Moving frontiers of science," organized by the Committee on AAAS Meetings. Because of the general interest of this program, the details of which will be announced later in a special release, all AAAS sections and most of the participating societies have scheduled no sessions concurrent with it. This symposium will be in the Statler ballroom.

The tenth annual Junior Scientists Assembly, sponsored by the association's Academy Conference, a full afternoon program exclusively for high-school students interested in careers in science, will be held in the large auditorium of the American Museum of Natural History on 27 Dec. Following the pattern of the Berkeley meeting's assembly, with the theme this year, "What makes a scientist," there will be an appropriate address, an industrial science show, a panel, and a concluding illustrated lecture. Program chairman is Zachariah Subarsky of the Bronx High School of Science.

Those concerned with various aspects of communications will find much to interest them in the six sessions of the fifth Conference on Scientific Editorial Problems, arranged by a committee headed by J. G. Adashko, Ford Instrument Company, and in the national meeting of the American Documentation Institute. It is probable that these programs will be cosponsored by one or more of the relatively new societies on technical writing. An interesting exhibit of the latest equipment for the storage and retrieval of information will be jointly sponsored by the ADI and the National Bureau of Standards. A noteworthy event of this year's program in chemistry will be the silver anniversary of the AAAS-Gordon Research Conferences, culmina-

ing in a dinner at which Glenn T. Seaborg, 1951 Nobel prize winner, will speak.

As the following synopsis of programs indicates, there will be interesting and important programs in all principal fields of science. In addition to the sessions for contributed papers that meet the needs of specialists, there will be a rich variety of symposia, and among these symposia there will be a number that are interdisciplinary and explore relatively neglected scientific areas—a type of program especially appropriate for an association of 264 affiliates and well over 50,000 individual members.

It is already apparent that the 123rd meeting will be one of the most significant in the long annals of the 108-year-old AAAS—and the attendance will be commensurate. The 18 sections of the association by themselves assure a large and diversified meeting but, in addition, some 40 societies and organizations are arranging programs of their own, and more than 50 others are participating as cosponsors. Fortunately, the session rooms of the Penn Zone hotels are sufficient in number to house nearly all the sessions and large enough to minimize crowding. The Hotel New Yorker will be headquarters for the Entomological Society of America; the Sheraton-McAlpin will house the science teaching societies; and the History of Science Society will be based at the Hotel Governor Clinton. All hotel headquarters assignments will be announced in the association's journals in July, at which time the advertising pages will begin to carry housing reservation and advance registration coupons. As in recent years, advance registrants will receive the book-size General Program-Directory early in December by first-class mail.

A synopsis of programs follows. The names given within parentheses are program chairmen.

Mathematics (A)

The *Association for Computing Machinery* (J. P. Nash, University of Illinois) is planning several sessions and the *Society for Industrial and Applied Mathematics* (Donald L. Thomsen, International Business Machines) is arranging a program of invited papers. Both organizations are meeting with the AAAS for the first time, and details are not yet available. It is anticipated that Section A (Rudolph E. Langer, University of Wisconsin) will cosponsor one or more of these sessions and will schedule a vice-presidential address.

Physics (B)

Section B (J. Howard McMillen, National Science Foundation) is organizing symposia on "Optics and oriented nuclei" (William B. Hawkins, Jr., Yale University), "Optical absorption in solids" (William F. Meggers, National Bureau of Standards), "Diffusion in solids" (H. B. Huntington, Rensselaer Polytechnic Institute), and "Crystal growth" (Nicholas Cabrera, University of Virginia); a fifth symposium on biophysics is under consideration. The Physicists' Dinner will be cosponsored by *Sigma Pi Sigma*, and the retiring vice-presidential address of Section B will be given by Alan T. Waterman of the National Science Foundation.

The *American Meteorological Society* (Kenneth Spengler, AMS) will cosponsor the Association of American Geographers' invited papers on climatology and other appropriate sessions.

Chemistry (C)

Section C's (Ed. F. Degering, Quartermaster Research and Development Laboratories, Natick, Mass.) full program includes sessions for contributed papers and symposia (Karl Folkers, Merck & Co.), the cosponsorship of Section Nd's symposium on "Antienzymes," and a vice-presidential address by Folkers. The symposia are on "Substances with selective toxicity" (Werner Braun, Rutgers University), 27 Dec.; "Steroids" (Boyd Woodruff, Merck & Co.), 28 Dec.; and "Organic chemistry" (Ellis Brown, Seton Hall University), 29 Dec. As mentioned earlier, the *AAAS-Gordon Research Conferences* will celebrate their silver anniversary with a dinner on 27 Dec., at which Glenn T. Seaborg will speak. *Alpha Chi Sigma* (H. G. Seavey, secretary of the New York Professional Chapter) is planning a meal function for all chemists.

Astronomy (D)

The *American Astronomical Society* (J. Allen Hynek, Ohio State University), for the first time in many years, will schedule its national meeting with the AAAS. The Hayden Planetarium of the American Museum of Natural History is cooperating. The Helen Warner prize lecture will be given by Harold Johnson of the Lowell Observatory. With the AAS providing a full program of sessions for contributed papers and other events, Section D's program will be restricted to cosponsorship of the AAS program and the retiring vice-presidential address of Seth B. Nicholson of the Mount Wilson Observatory.

Geology and Geography (E)

Section E (Robert L. Nichols, Tufts University) will have sessions for contributed papers in geology; a four-session symposium, "Geochronometry"

(J. Laurence Kulp, Columbia University), one session of which, on "Carbon dating," will be cosponsored by Section F; "Ground water" (A. Nelson Sayre, U.S. Geological Survey); and "Appalachian structure and stratigraphy" (Kurt E. Lowe, City College, New York)—all cosponsored by the *Geological Society of America.* Symposia on "Carbonate sedimentation" and "Uranium geology," as well as a panel on the International Geophysical Year, are being considered. Section E will cosponsor the sessions of the special meeting of the *Association of American Geographers* (Peter M. Stern, Conservation Foundation), with the New York Metropolitan Division as host, which will include sessions for contributed papers in geography and invited papers on climatology. Section E's customary Geologists' Smoker will include the retiring vice-presidential address of Carl Tolman. The *National Geographic Society* will have its usual excellent lecture and accompanying film—one of the special evening sessions—and the *National Speleological Society* (Brother G. Nicholas, Cumberland, Md.) again will hold a general session for contributed papers and a social hour.

Zoological Sciences (F)

The program of Section F (H. H. Plough, Amherst College) includes a symposium on "Museum techniques" cosponsored by the *American Museum of Natural History* (Gordon Reekie, manager of exhibition and construction, American Museum of Natural History); cosponsorship of the two-session symposium, "Communication in the social insects," of the International Union for the Study of Social Insects; a symposium, "Problems of aging" (Howard J. Curtis, Brookhaven National Laboratory)—topics: "Aging in lower organisms," "Physiological aspects of aging in mammals," "Aging in populations," and "Radiation-induced aging"; a symposium, "The biochemistry of the cell nucleus" (A. W. Pollister, Columbia University), jointly with the *Genetics Society of America*—topics and speakers are: "Introduction," A. W. Pollister; "The correlation of nucleic acid content with chromosome complement," Cecilie Leuchtenberger; "The time of synthesis of desoxyribose nucleic acid," J. Herbert Taylor; "Changes in the interphase nucleus with cellular function," Max Alfert; and "Chemical studies of the giant chromosomes of Diptera," George T. Rudkin. Section F will cosponsor "Carbon dating," part II of Section E's symposium on "Geochronometry" (J. Laurence Kulp, Columbia University); the joint symposium of the *New York Zoological Society* and the *New York Academy of Sciences* (Ross F. Nigrelli, New York Zoological Society); the symposium of the *American Society of Zoologists* (Rudolph T. Kempton, Vassar College); and a symposium, jointly with Section G, on "Problems of aging in plants and animals." The Zoologists' Luncheon for all zoologists will feature the vice-presidential address of Bentley Glass. Contributed papers submitted to Section F will be joint with the societies just mentioned or immediately following.

The 4 days of concurrent sessions of the annual national meeting of the *Entomological Society of America* (P. W. Oman, Plant Industry Station, Beltsville, Md.), which last met with the association in 1947, are scheduled for 27–30 Dec., inclusive, at the Hotel New Yorker. The *Herpetologists League* (James A. Fowler, Academy of Natural Sciences of Philadelphia) is planning a regional meeting of contributed papers. The *International Union for the Study of Social Insects, North American Section* (T. C. Schneirla, American Museum of Natural History), in addition to the symposium on "Communication in the social insects"—part I, "Perspectives on fact and theory for the principal social insects" and part II, "Special problems concerning techniques, modalities, and potentialities"—will sponsor a symposium, "The effects of radiation on insects" (Orlando Park, Northwestern University), jointly with the *Ecological Society of America.* The national annual meeting of the *Society of Systematic Zoology* (R. E. Blackwelder) will follow the pattern of former meetings with the association, with sessions for contributed papers, one or more panels or symposia—one of them jointly with the Entomological Society of America—evening lectures, and a business meeting. A feature will be the annual SSZ Library and Lounge for all zoologists.

The New York Zoological Park (Bronx Zoo) will sponsor a daily guided tour throughout the meeting period, 27–31 Dec., beginning at the administration building at 11 A.M. (John Tee-Van, director).

Biological Sciences (FG)

The *Ecological Society of America* (Murray F. Buell, Rutgers University) will have sessions for contributed papers, two sessions of invited papers, "Ecology in the Northeast and its applications," and a group of papers on animal behavior and sociobiology (J. P. Scott, Jackson Memorial Laboratory); the symposium, "The effects of radiation on insects," of the International Union for the Study of Social Insects and the grassland ecology part of Section O's symposium on grasslands will be cosponsored. The symposium of the Genetics Society of America has been mentioned under Section F.

The *Society for the Study of Evolution* (Harlan Lewis, University of California at Los Angeles), which last met with the AAAS in 1949, in addition to sessions for contributed papers and a business meeting, will have a symposium, "Biotic communities in the past and today," with Jens C. Clausen as chairman. Titles of papers and speakers are "Genic variability in relation to environment," J. C. Clausen; "Migration of Cenozoic forest communities in North America," Erling Dorf; "Rise of the grass-eating mammals," Joseph T. Gregory; and "Man changing the environment"; this program will be cosponsored by the *Society of Vertebrate Zoology* and other societies.

It is expected that the *American Society of Naturalists* (Bruce Wallace, Cold Spring Harbor, N.Y.) will either arrange a symposium or cosponsor one in the F, FG, or G series.

The annual national meeting of the *National Association of Biology Teachers* (John Breukelman, State Teachers College, Emporia, Kan.) will begin with a business meeting, 26 Dec. It will include three general programs, a luncheon on 27 Dec., a joint session with the other science teaching societies, and a session at the American Museum of Natural History. A field trip with the American Nature Study Society on 30 Dec. will conclude the meeting. The *Society of General Physiologists* (Abraham Shanes, National Institutes of Health) plans a symposium and one or more sessions for contributed papers.

Botanical Sciences (G)

Section G (Barry Commoner, Washington University) will have a two-session symposium, "Problems of aging plants and animals" (Paul J. Kramer, Duke University), jointly with Section F; and a second symposium, "Some unsolved problems in biology"—for example, the chemistry of inheritance, mechanisms of growth and development—(Barry Commoner) cosponsored by Section F and various societies including the *Botanical Society of America* and commemorating this society's golden anniversary. Section G will cosponsor Section O's grassland symposium. The vice-presidential address by Paul J. Kramer will follow the Botanists' Dinner, 27 Dec., a special occasion further celebrating the 50th anniversary of the Botanical Society of America. Sessions for contributed papers in plant ecology, plant physiology, and general botany will be held jointly with the *Ecological Society of America* and the *Torrey Botanical Club* (David Keck, New York Botanical Garden). The Torrey Botanical Club will also arrange a program, probably in the field of plant taxonomy.

Anthropology (H)

The full program of Section H (Gabriel Lasker, Wayne University College of Medicine) includes sessions for contributed papers; a symposium to commemorate the 100th anniversary of the discovery of the Neanderthal man (Loren C. Eiseley, University of Pennsylvania, and William L. Straus, Jr., Johns Hopkins University), sponsored jointly with the *American Institute of Human Palaeontology*; a two-session symposium, "Man in the tropics" (Vera Rubin, Columbia University), with speakers from both the United States and Caribbean areas; an Anthropologists' Dinner with one or more addresses by W. Montague Cobb and perhaps other recent vice presidents of Section H. Section Nd's symposium, "Forensic dentistry," will be cosponsored.

Psychology (I)

Section I (Conrad G. Mueller, Columbia University) has arranged sessions for six groups of invited papers, four of which are "Experimental psychopathology," "Physiological mechanisms of motivation and reward," "Sensory functions," and "The place of experimental psychology in anthropological field work." It is anticipated that there will be sessions for contributed papers and that Section I will cosponsor parts of Section N's symposium, "Evolution of nervous control from amoeba to man." The vice-presidential address will be given by Clarence H. Graham of Columbia University.

Social and Economic Sciences (K)

Section K's symposium, "The impact of the natural sciences on the social sciences: an interpretation" (Donald P. Ray, George Washington University), will be of general interest. It is cosponsored by the *American Political Science Association* and the *American Sociological Society.* Section K will cosponsor the symposium, "Science and national security" (Benjamin H. Williams, Industrial College of the Armed Forces), of the *National Academy of Economics and Political Science* with the collaboration of *Pi Gamma Mu,* the national honorary society in the social sciences, which, it is anticipated, will have a dinner for the speakers of Section K.

The *Society for the Advancement of Criminology* (Donal E. J. MacNamara, New York Institute of Criminology) will hold a special meeting with the theme, "Science fights the criminal," and lecture-demonstrations of new instruments and techniques; a Criminologists' Luncheon is planned.

History and Philosophy of Science (L)

The program of Section L (Jane M. Oppenheimer, Bryn Mawr College) comprises two sessions for contributed papers, a joint session and dinner with the History of Science Society, a business meeting, the vice-presidential address of Henry Guerlac, and a two-session symposium, "Science and ethics" (Joseph Mayer, Miami University, Ohio), probably cosponsored by the *Philosophy of Science Association*, which plans five sessions on measurement. Section L will cosponsor the special meeting of the *American Philosophical Association, Eastern Division* (John Wild, Harvard University) commemorating the 100th anniversary of the birth of Sigmund Freud.

The annual national meeting of the *History of Science Society* (Pearl Kibre, Hunter College) begins with business meetings on 27 Dec.; includes the symposium, "The interaction of science and technology," joint with Section L, and a luncheon and report on the international conference, 28 Dec.; and concludes, 29 Dec., with two symposia, "The impact of ancient science on the Middle Ages" and "The history of medicine: interpretations and advocates." The *Society for the Advancement of General Systems Theory* (Ludwig von Bertalanffy, Mt. Sinai Hospital, Los Angeles) will have a business meeting and a session for contributed papers, 29 Dec., and a symposium, 30 Dec.

Engineering (M)

Section M (Clarence E. Davies, ASME) has set up a program committee to plan and implement a three-session symposium (Irving P. Orens, Newark College of Engineering) entitled "Man and his physical environment," scheduled for 26 and 27 Dec. Part I will deal with "The present integration of man and machines"; part II, "The future integration and necessity for new machines"; and part III, "Machines and progress in the mechanical translation of languages." The *Engineering Manpower Commission* will cosponsor the sessions of the Conference on Scientific Manpower.

Medical Sciences (N)

As in previous years, Section N will have a four-session symposium, the participants of which come from all parts of the continent. This symposium is scheduled for 29 and 30 Dec. This year's subject, "Evolution of nervous control from amoeba to man" (Bernard B. Brodie, National Institutes of Health), will range from the rudiments of intracellular phenomena in protozoans through intercellular communication and neurohumors in both invertebrates and vertebrates to the basic actions of drugs on animal and human behavior; included will be the vice-presidential address of Irvine H. Page, and the announcements of the 12th Theobald Smith award, given by Eli Lilly and Company, and the second AAAS-Anne Frankel Rosenthal Memorial Award in Cancer Research. Part of this symposium may be cosponsored by the Society of General Physiologists and Section I. Section N will cosponsor a variety of appropriate programs.

Alpha Epsilon Delta (Maurice L. Moore, national secretary) will have its customary annual luncheon and a speaker of prominence. Details of the special programs of the *American Association of Hospital Consultants* (E. Dwight Barnett, Columbia University), the *American Psychiatric Association* (Benjamin Pasamanick, Ohio State University Health Center), and the *American Physiological Society* (Fred A. Hitchcock, Ohio State University) are not yet available.

Dentistry (Nd)

On 28 Dec. Section Nd (George C. Paffenbarger, American Dental Association Research Fellowship, National Bureau of Standards) will have sessions for contributed and invited papers, "Contributions of science to everyday practice." On 29 Dec. there will be a symposium, "Forensic dentistry" (W. M. Krogman, University of Pennsylvania), cosponsored by Sections H and N; a luncheon; a second symposium, "Antienzymes," cosponsored by Sections C, N, and Np; and a business meeting. The entire program of the section will be cosponsored by the *American College of Dentists*, the *American Dental Association*, and the *International Association for Dental Research, North American Division*.

Pharmacy (Np)

The full program of Section Np (John E. Christian, School of Pharmacy, Purdue University) begins 26 Dec. with an evening session for contributed papers and continues 27 Dec. with the vice-presidential address of Rudolph H. Blythe, contributed papers, and a symposium, "The significance of cosmetics in medical practice," cosponsored by the *Committee on Cosmetics of the American Medical Association*. On 28 Dec. there will be a symposium, "Tablet manufacture," and papers, and, on 29 Dec., the Hospital Pharmacy program and Section Nd's "Antienzymes." Sec-

ion Np's entire program will be cosponsored by the *American Association of Colleges of Pharmacy*, the *American College of Apothecaries*, the *American Pharmaceutical Association, Scientific Section*, and the *American Society of Hospital Pharmacists*.

Agriculture (O)

Section O (H. B. Sprague, Pennsylvania State University) will have a four-session symposium, "Grasslands in our national life," 29 and 30 Dec. Part I deals with "Forage utilization and related animal nutrition problems"; part II, "Forage production in humid regions"; part III, "Applications of plant sciences to grasslands"; and part IV, "Grassland machinery, equipment, and irrigation systems." Among the many organizations expected to cosponsor appropriate portions of this symposium are Section G, American Dairy Science Association, American Institute of Nutrition, American Phytopathological Society, American Society of Agricultural Engineers, American Society of Agronomy, American Society of Animal Production, American Society of Biological Chemists, American Society of Plant Physiologists, American Veterinary Medical Association, Botanical Society of America, Ecological Society of America, Entomological Society of America, Farm Equipment Institute of America, Genetics Society of America, Soil Conservation Society of America, and Soil Science Society of America.

Industrial Science (P)

Section P (Allen T. Bonnell, Drexel Institute of Technology) will hold a two-session symposium and a luncheon session at which Earle L. Rauber of the Atlanta Federal Reserve Bank will give the vice-presidential address.

Education (Q)

The program of Section Q (Herbert A. Smith, University of Kansas) includes two sessions joint with the *International Council for Exceptional Children*, 26 Dec.; two sessions joint with the *American Educational Research Association*, 29 Dec.; some four sessions for contributed papers, 29–31 Dec.; a business meeting, 30 Dec.; and the vice-presidential address of Dean A. Worcester. This section will cosponsor appropriate sessions of the programs of the science teaching societies—all of which (J. Darrell Barnard, New York University, Washington Square) are cosponsoring the AAAS General Symposium, "Moving frontiers of science," holding a joint mixer the evening of 26 Dec. and a joint session the evening of 27 Dec.

Additional sessions of the regional meeting of the *National Science Teachers Association* (Alfred D. Beck, New York Board of Education) are tours, 26 Dec.; a Business-Industry Luncheon, 27 Dec.; and concurrent sessions, 28 and 29 Dec. The *National Association for Research in Science Teaching* (Nathan Washton, Queens College) will meet on 27 Dec. and will also participate in the joint session of the science teaching societies that evening. The *AAAS Cooperative Committee on the Teaching of Science and Mathematics* (Morris Meister, Bronx High School of Science) will probably hold a panel discussion on the proposed extension of the Smith-Hughes Act, which would provide federal subsidies for science and mathematics teachers; and it will cosponsor the Junior Scientists Assembly of the Academy Conference.

Science in General (X)

The annual *Academy Conference* (Leland H. Taylor, West Virginia University), composed of delegates and other members of the 41 academies affiliated with the association, will hold a day of sessions, 29 Dec., and will sponsor the tenth annual Junior Scientists Assembly.

Details of the annual national meeting of the *American Documentation Institute* (James W. Perry, Western Reserve University), which is meeting with the AAAS for the first time, are not yet available; one feature, however, will be an exhibit of the latest equipment for the storage and retrieval of data, jointly sponsored by the ADI and the National Bureau of Standards. The *American Geophysical Union* (Waldo E. Smith, AGU) probably will cosponsor the session on climatology of the Association of American Geographers and other appropriate programs within the wide range of the interests of its membership.

The annual national meeting of the *American Nature Study Society* (Richard L. Weaver, University of Michigan) includes an opening session on the afternoon of 26 Dec. and the joint mixer that evening; the joint session of the science teaching societies, 27 Dec.; a session, 28 Dec.; and, with NABT, a joint session, 29 Dec., and a joint field trip, 30 Dec. The ANSS banquet and showing of Kodachromes is scheduled for the evening of 29 Dec.

The fifth *Conference on Scientific Editorial Problems* (J. G. Adashko, Ford Instrument Company) will hold six (nonconcurrent) sessions on various aspects of scientific and technical writing, editing, and publishing; it is expected that one of

these sessions will be concerned with foreign translation problems. The program will be coordinated with the sessions of the American Documentation Institute so that potential conflicts are eliminated or minimized.

The recurrent *Conference on Scientific Manpower* (Thomas J. Mills, National Science Foundation) is scheduled for 4 P.M., 26 Dec. As in previous years, it will be cosponsored by the *Engineering Manpower Commission,* the *Scientific Manpower Commission,* the *National Academy of Sciences–National Research Council,* and the *National Science Foundation.*

The national meeting of *Sigma Delta Epsilon,* graduate women's science fraternity (Clyde Chandler, Boyce Thompson Institute) begins with a business meeting, 26 Dec., and includes the annual dinner and grand chapter meeting on 27 Dec., a luncheon for all women in science on 29 Dec., and probably a tea on 30 Dec. A headquarters room will be maintained throughout the meeting period.

The *National Association of Science Writers* (Roland H. Berg, *Look* Magazine) will have its annual symposium and a business meeting with the AAAS. The annual address and award of the William Procter prize of the *Scientific Research Society of America* is scheduled for the evening of 26 Dec., preceding the society's joint luncheon with the Society of the Sigma Xi and the annual convention of RESA on 27 Dec. The annual address of the *Society of the Sigma Xi* will be held the evening of 27 Dec., following the 57th annual convention of the society on that day. The 17th annual lecture of the *United Chapters of Phi Beta Kappa* is scheduled for the evening of 27 Dec.

Societies and organizations participating in the AAAS meeting are as follows:

National annual meetings: Academy Conference; American Astronomical Society; American Documentation Institute; American Nature Study Society; Conference on Scientific Editorial Problems; Conference on Scientific Manpower; Entomological Society of America; History of Science Society; National Association of Biology Teachers; Scientific Research Society of America; Sigma Delta Epsilon; Society for the Advancement of General Systems Theory; Society of the Sigma Xi; Society for the Study of Evolution; Society of Systematic Zoology.

Special or regional meetings, with programs: AAAS Cooperative Committee on the Teaching of Science and Mathematics; AAAS-Gordon Research Conferences; Alpha Chi Sigma; Alpha Epsilon Delta; American Association of Hospital Consultants; American Philosophical Association, Eastern Division; American Psychiatric Association; American Society of Zoologists; Association of American Geographers; Association for Computing Machinery; Ecological Society of America; Genetics Society of America; Herpetologists League, International Union for the Study of Social Insects, North American Section; National Academy of Economics and Political Science; National Association for Research in Science Teaching; National Association of Science Writers; National Geographic Society; National Science Teachers Association; National Speleological Society; New York Academy of Sciences; New York Zoological Park; New York Zoological Society; Pi Gamma Mu; Society for the Advancement of Criminology; Society of General Physiologists; Society for Industrial and Applied Mathematics; Torrey Botanical Club; United Chapters of Phi Beta Kappa.

Cosponsors: American Association of Colleges of Pharmacy; American College of Apothecaries; American College of Dentists; American Dairy Science Association; American Dental Association; American Educational Research Association; American Geophysical Union; American Institute of Human Paleontology; American Institute of Nutrition; American Medical Association, Committee on Cosmetics; American Meteorological Society; American Museum of Natural History; American Pharmaceutical Association, Scientific Section; American Physiological Society; American Phytopathological Society; American Political Science Association; American Society of Agricultural Engineers; American Society of Agronomy; American Society of Animal Production; American Society of Biological Chemists; American Society of Hospital Pharmacists; American Society of Naturalists; American Society of Plant Physiologists; American Sociological Society; American Veterinary Medical Association; Botanical Society of America; Engineering Manpower Commission; Farm Equipment Institute; Geological Society of America; International Association for Dental Research, North American Division; International Council for Exceptional Children; National Academy of Sciences–National Research Council; National Bureau of Standards; National Science Foundation; Philosophy of Science Association; Scientific Manpower Commission; Sigma Pi Sigma; Society of Vertebrate Zoology; Soil Conservation Society of America; Soil Science Society of America.

RAYMOND L. TAYLOR
Associate Administrative Secretary, AAAS

Theobald Smith Award

Nominations are requested for the AAAS Theobald Smith award of $1000 and a bronze medal, which has been given yearly since 1937 (except for a lapse during the war years) by Eli Lilly and Company under the auspices of the AAAS. The award will be presented at the association's 123rd meeting in New York, 26–31 December.

The prize is given for "demonstrated research in the field of the medical sciences, taking into consideration independence of thought and originality." Any U.S. citizen who was less than 35 years of age on 1 January 1956 is eligible. Research is not judged in comparison with the work of more mature and experienced investigators. The vice president of AAAS Section N–Medical Sciences and four fellows will form the committee of award.

Nominations may be made by fellows of the AAAS. Six copies of all data to be submitted should be sent *before 1 September* to the secretary of Section N, Dr. Allan D. Bass, Department of Pharmacology, Vanderbilt University School of Medicine, Nashville 5, Tenn.

Academy Grants for Student Research

The AAAS announces a new program for the use of the research funds that are awarded by the association to the academies of science. Effective at once, but optional until 1957, the academies are requested to use the grants for the assistance of high-school and college students rather than senior scientists.

Carefully selected students will receive modest amounts to buy equipment or books to assist them in carrying out original investigations. Each recipient will have to report his project in the same way that a senior scientist must when he seeks support from a foundation or a Federal Government agency.

The association believes that experience in original investigation cannot begin too early; further, the solving of even a simple problem in the laboratory or in the field can provide an important stimulus to the young mind.

It should be noted that these grants are not "prizes" for work well done. The emphasis is on the encouragement of, and assistance to, a student who has an idea that he wants to develop. However, students who have already won prizes or awards are not excluded from consideration for grants for new projects.

The academies are being asked to give preference to high-school students. College students in the smaller colleges may be eligible if the college is unable to supply what is needed. Each academy may decide whether equipment purchased for any project is to become the property of the grant recipient or the school or college, or whether it should be turned over the academy for reissue to other students.

The amount of an academy award depends on the number of members who are also members of the AAAS. The association provides a minimum of $50 to each participating academy. If all grant funds are not used in a given year, the balance may be spent at any time within 2 years. Students and teachers interested in this new program should communicate with the nearest academy that is affiliated with the AAAS or write to the association for information.

JOHN A. BEHNKE
Associate Administrative Secretary, AAAS

Editor for Journals

The AAAS is very pleased to announce that Graham DuShane will continue on a permanent basis as editor of *Science* and *The Scientific Monthly.* Since 1 January DuShane has served as editor, while on leave of absence from his position as professor of biology at Stanford University. He has submitted his resignation to Stanford in order to accept the editorship.—D. W.

Assistant Director for STIP

Irvin E. Wallen, associate professor of zoology and chairman of biological science courses at Oklahoma Agricultural and Mechanical College, has been granted a year's leave to serve as assistant director of the AAAS Science Teaching Improvement Program (STIP). He has already assumed his post in Washington.

Wallen holds a B.A. and an M.A. degree from Oklahoma A. and M. and a Ph.D. from the University of Michigan. He was a teaching fellow at Michigan before he started his full-time teaching career in 1948 as instructor at Oklahoma A. and M. His research has included water-pollution studies, and recently he helped the petroleum refiners in Oklahoma to organize a waste-control council.

Wallen's activities at Oklahoma A. and M. especially qualify him for service on the STIP program.

He has served on a number of university committees, particularly those concerned with teacher education and the relationship of the college to secondary schools. In addition, during the past year he has been chairman of the science education section of the Oklahoma Academy of Science. One of his responsibilities in STIP will be to work with state academies.

STIP Study on Use of Science Counselors

Administrative agreements have been signed with the University of Nebraska, University of Oregon, Pennsylvania State University, and University of Texas for the Study on the Use of Science Counselors that is being sponsored by the AAAS Science Teaching Improvement Program. Under the agreement, STIP provides a grant to each university to operate a center for the study. Each university will name a coordinator for the center and employ two experienced teachers to serve as science counselors during the academic year 1956–57. The counselors will visit secondary schools in the territory surrounding the university, assisting and counseling with the science and mathematics teachers in these schools.

It is suggested that as many high schools be included in a center as will be required to include 100 to 150 full-time science and mathematics teachers. In each center an advisory committee, consisting of representatives of the departments of biology (botany and/or zoology), chemistry, education, mathematics, and physics, will be established.

It is the purpose of the Study on the Use of Science Counselors to test a method for increasing the competence of teachers, many of whom are relatively inexperienced and may be lacking in several aspects of desirable preparation. Many teachers of science would profit from improved laboratory and demonstration techniques and greater knowledge of subject matter, with stress on recent developments.

It is hoped that the study will be completed before the scarcity of science teachers reaches its peak, and that the results will point to a method for alleviating the shortage, perhaps a method that will merit support by public funds. It is believed that a science counselor with desirable breadth and depth of training in the sciences and mathematics, with a background of outstanding accomplishment in teaching, a natural ability to work with people, and practical knowledge of the learning process, can stimulate and improve the work of a small group of less well prepared and more inexperienced teachers.

In addition to making effective use of teacher counselors, the study is intended to bring staff members in science, mathematics, and education into closer working relationships on a problem of common concern, and to bring college and university science staffs into closer communication with secondary schools. The study will provide for direct services by the universities to secondary schools. The university will be responsible for forming satisfactory working relationships with the participating schools and for obtaining the approval and cooperation of the state departments of education. It is suggested that whenever possible a counselor be made at least a nominal member of the state education department.

The centers were selected by an advisory board that consists of J. W. Buchta, professor of physics at the University of Minnesota; John Richardson, professor of science education at Ohio State University; and B. L. Dodds, dean of the College of Education at the University of Illinois. The director of STIP is chairman. The center coordinators are also to serve as members of the advisory board. The board will plan an evaluation of the study with the assistance of the centers and the cooperating schools.

The Study on the Use of Science Counselors will continue through one academic year, for which the grants have been made, and it is expected that the project will be extended for a second year. A 5-day conference for center coordinators and counselors was held on the campus of the University of Colorado 19–23 June.

JOHN R. MAYOR
Director, Science Teaching Improvement Program

Nature is never in a hurry, and seems to have had always before her eyes the adage, "keep a thing long enough and you will find a use for it."—T. H. HUXLEY, "Discourses, Biological and Geological," *Collected Essays* (London 1893–94).